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VOLUME XXVIII NOVEMBER, 1913 NUMBER 1

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Vol. XXVIII November, 1913 No. 1

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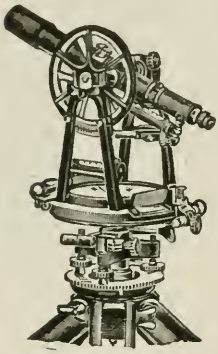

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The Technograph

Vol. XXVIII November, 1913 No. 1

UNDERLYING PRINCIPLES OF GOOD ILLUMINATION, AS APPLIED IN MODERN SYSTEMS

BY LEONARD V. JAMES, E. E.

Associate in Electrical Engineering

(This article is the first of a series of three promised The Technograph by the author, dealing with the manner in which modern demands in matters of illumination are being met by advocates of indirect lighting. Failure to announce improvements which have been made in direct lighting equipment should not be misconstrued into meaning that there have been none such—they are not within the scope of this series. Acknowledgment is due the National X-Ray Reflector Co. of Chicago, pioneers and leaders in this field, for the photographs in this article and for data and illustrations for the ones to follow.)—The Editor.

The progress which has been made in the past decade in the matter of illumination is little short of wonderful. There have been two principle causes for this development. In the first place, as has recently been stated in the editorial column of a large daily, night work has come to stay; in other words modern commercialism demands a longer day than that afforded by daylight. In the second place, important developments in the lighting units themselves have not only made better illumination possible but they have actually forced the consumer to demand protection from eye-strain and the central station manager to seek a larger field, both of which conditions are being satisfied by better illumination.

The history of modern lighting really dates back only to 1879, when Edison perfected the incandescent lamp and placed it on the market as a competitor against gas, arc and oil lamps. The competition at first was not keen because of the cost of electric power, and the oil lamp remained in general use until within recent years. Because of the generally poor diffusion and distribution in vogue during this period there was at no time real de-

mand for adequate and proper illumination, even in places where it would now seem absolutely necessary. There were a few who claimed that the eyes would suffer unless a more nearly uniform lighting was secured, but such bad effects as did appear developed gradually so that most people did not take the matter seriously. The system which flourished under this condition involved exposed lighting units, of which the bare incandescent lamp or the lamp enclosed by a practically transparent shade are fair examples.

Just as the invention of the Welsbach mantle permitted a much more brilliant light-source at the gas jet, so has the tungsten or mazda lamp provided a brighter source for the electric fixture. For not only has this new unit a much better efficiency than the older carbon lamp, but its filament may be heated to a higher temperature, causing it to glow at a greater intensity or brilliancy. The immediate result of its introduction, aside from encouraging a more extended use of electricity for lighting, has been to exaggerate the previous lack of uniformity in illumination, making it more uncomfortable and thus forcing people to take notice. Another result has been the aroused interest among central station men in behalf of better and proper lighting, their end in view being to keep this high efficiency unit from reducing the loads on their plants and thus their cash returns, as well as to advance a good cause. The combined effect is apparent in the very general interest which is now being displayed in all civilized parts of the world, in this matter of "proper illumination."

Because of the laxity in the use of qualifiying terms, especially in speaking of illumination, it is well to consider what is or should be meant by "good illumination"; also to ascertain in what manner and to what extent the claimed improvements in lighting are real improvements and the amount of additional trouble and expense which they merit, when compared with the so-called inadequate, improper and obviously cheaper installations.

To answer these questions it is necessary only to investigate the purpose of providing artificial lighting and to determine the manner in which these improvements affect the accomplishment of that purpose. Inasmuch as the only need for illumination is for seeing, it is evident that this investigation involves a study of the eyes and the manner and conditions under which these

organs best perform their function. This matter can be treated but briefly in this article.*

The pupil and retina are the two essential parts of the eye which determine and are most affected by the quantity and distribution of the light. Figures 1 and 2 show very clearly the

Fig. 1. Pupil of eye expanded to let in plenty of light when illumination is dim.

Fig. 2. Same pupil as in Fig. 1, contracted to shut out excessive light.

manner in which the pupil acts to control the amount of light entering the eye, the muscles contracting and closing the opening when necessary to shut out some of the rays. The range through which this action is possible is relatively small,—about one hundred to one.

The retina is the nerve or sensitized plate upon which the light rays strike and which conveys the impression to the brain. That this nerve can operate very satisfactorily throughout a considerable range of light intensities is evidenced by the fact that the normal person can read print of medium size with comparative ease either with the illumination provided by a full moon or with that of the noon-day sun—a range of over 10,000 to 1, indicating that the retina has a range of at least of 100 to 1. Of course, no one would try to work continuously under either of the extreme conditions noted. In fact, just as normal conditions of life limit the range of temperature or of noise to which a person may directly be exposed without discomfort or actual injury, so the conditions under which we work determine to a considerable extent the definite intensity in illumination for which our eyes are best adapted. Should it seem desirable, this intensity could

*A very simple but excellent treatise entitled "Light: Its Use and Misuse" and known as a Primer of Illumination may be secured by forwarding ten cents to the Illuminating Engineering Society, 29 West 30th St., New York. This primer contains 21 pages of very interesting information, prepared by experts.

be altered somewhat without serious inconvenience to the user, but not without his noticing it. Thus the average illumination on the desk of the author at night has been found to be five foot candles while that on the same desk in the daytime is from one to ten or twenty times that amount. This is under ordinary working conditions.

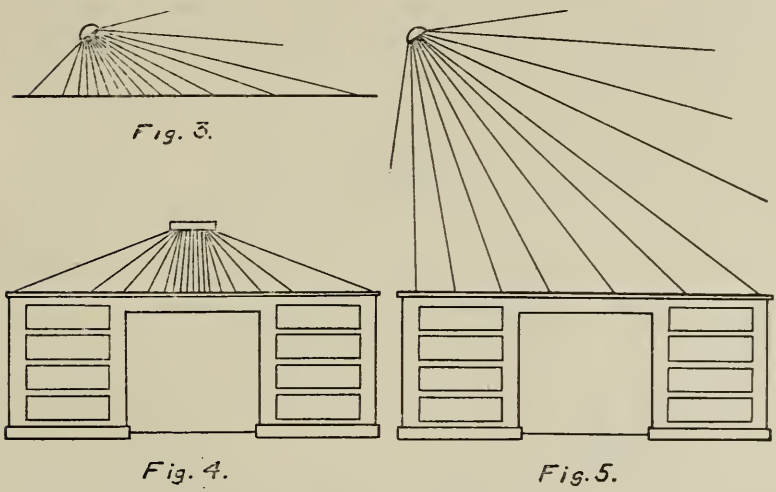
The real problem in planning for artificial illumination is therefore not so much the amount of light as the manner in which it is applied. The ideal light-source would naturally be one which would give a uniform number of rays upon the work from all directions, a condition which may be approached with daylight. But daylight is free, artificial light costs, and economy must be considered. As a result we find tables stating definitely the light in foot-candles desirable for different classes of interiors such as parlors, offices, drafting-rooms, etc., these tables indicating the probable minimum lighting which most eyes would need to discern clearly the objects in the room or to perform the work required of them. In many cases the values given could be lowered if good distribution and diffusion were assured, as is later explained.

Distribution and diffusion are by no means synonymous terms. By good distribution is meant uniform lighting, usually having reference to the "working plane," a plane parallel to the floor and from two to three feet above it. Such a result may be secured from a point-source equipped with the proper reflector. (See Fig. 7.) To be diffused, the light rays producing illumination at any point must come from all directions so that there can be no regular reflection. It is sometimes impossible to secure this effect because of the nature of the material, as in the case of polished metal or furniture, but no installation should be countenanced where conditions of good distribution and diffusion are not at least approached.

The logical question following such a statement as the above is, "Why are good distribution and diffusion desirable, when the eye can be shown to operate satisfactorily throughout so great a range?" The answer is easily found. Try first to read a newspaper held a foot beyond an exposed incandescent lamp, then place a piece of cardboard between the lamp and the eye and try again to read the paper. The amount of illumination on the sheet is practically the same under each condition. In the first case, however, a large part of the retina is greatly over-excited

by the direct rays and is unable to distinguish the characters. The pupil tries to protect this part by contracting and in doing so prevents the rest from securing enough light for it to operate, thus completely disabling the organ. Contrast this with the comparative ease with which the paper is read in the second case. Also notice that the "eye-strain" in the first case is very unpleasant and would soon prove injurious.

One is not likely to encounter quite so extreme a case as the above in practice and yet a little eye-strain for a long time will do as much or more damage than the greater strain for a short time. Figures 3 and 4 show how a desk-lamp may provide many



Figs. 3 and 4. Poor distribution of light over desk.
Fig. 5. Good distribution in desk lighting.

times as much illumination near the lamp as is to be found at the edge of the desk. To check this the writer investigated a few desks in actual use in university offices and soon found one where the relation of maximum to minimum illumination was about one hundred to one. In such a case, one can imagine the different parts of the eye trying to make the rest accommodate itself to the intensity to which those parts are exposed, the result being a tug-of-war or wrestling bout which would soon weary the worker. Neither more nor less light nor spectacles can correct this trouble, except that a fixture in the center of the room, designed to provide general illumination, can reduce the ratio and help improve the condition. If the desk must be lighted by an individual lamp, an arrangement is suggested in Fig. 5 which will not provide so

much light if the same lamp is to be used, but will correct to a considerable extent the poor distribution.

Probably the worst offender in this matter of differences in light intensity within the range of vision is the exposed source. Direct lighting (i. e. not by reflection) is all right in many places, but it should never be possible for the direct rays from the electric bulb or other bright source to enter the eye of the one using the light. Churches should recognize this principle and discontinue the practice of wearying the audience and handicapping the preacher, because of the lamps exposed to view for at least a part of the services. Another fault of the same character is the presence of glare or regular reflection from the desk or paper or from objects in the room. One need not look directly at this glare to have it affect him, it needs only to be within the range of his

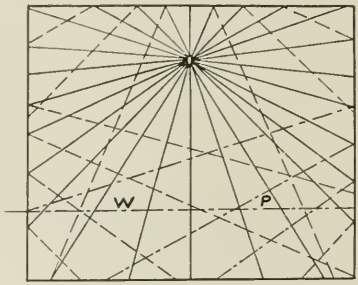


Fig. 6

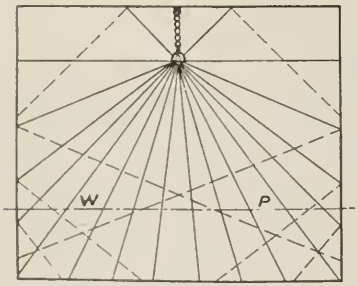


Fig. 7

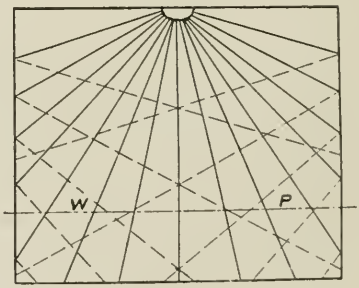


Fig. 8

Fig. 6. Exposed lamp. About the same illumination on ceiling, walls and working-plane. No diffusion. Light in eyes. Should not be used.

Fig. 7. Nearly opaque shade designed to distribute over working-plane and accomplishing that result. Ceiling and top walls in shadow. Eyes protected. Good in combination for drafting room. No diffusion except as the light from a number of lamps over-lap.

Fig. 8. Hemispherical bowl. Pleasing general effect. Enlarged light-source of moderate intensity. Practically no diffusion.

vision. Further experiments like the one already suggested with an incandescent lamp and newspaper will illustrate this principle.

Another offence through differences in intensity is in the presence of dense shadows. As in the case of glare, these shadows need only be within the range of vision to cause part of the eye to attempt to become adapted to their intensities, in spite of the tendency of other parts to bring about an accommodation to a higher illumination. Thus the desk should not be much more brilliantly lighted than other objects within view. This is contrary to the advice of some who advocate higher illumination of one's work to prevent mind-wandering—a condition which really calls for mental control rather than poor lighting and eye-strain. Within certain limits both direct reflection and shadow are desirable in order to avoid flatness, so that after all, the matter of contrast must be balanced against possible eye-strain.

The evils of glare and dense shadows are being overcome by the combination of light direction and enlargement of light-sources. Through directing the rays by means of proper reflectors, the light may be distributed as desired and the eyes protected. By enlarging the source emitting a given amount of light-energy, the brilliancy of that source is decreased. Another effect of increasing the size of the source is in the greater diffusion

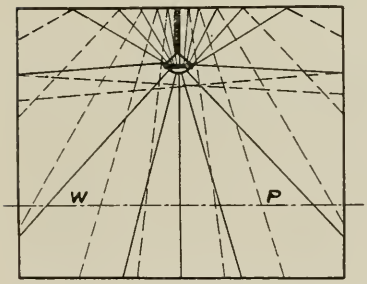


Fig. 9

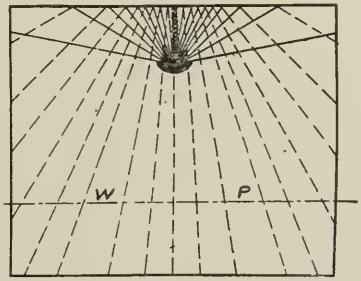


Fig. 10

Fig. 9. "Semi-indirect" lighting. Approximately half of the light directed to the ceiling and reflected downward, the rest passing down through a more or less dense bowl. A pleasing combination of direct and indirect, with probable lower efficiency than either. Fixture lighted to moderate intensity, ceiling of low intensity. Considerable diffusion.

Fig. 10. Indirect with opaque reflectors and bowl. All of light reflected from ceiling which constitutes a low-intensity source. Gives very good diffusion and distribution, and, under favorable conditions, has as high an efficiency as direct lighting. In the luminous bowl type of indirect fixture, art or frosted glass is used in the bowl and is lighted to about the same intensity as the ceiling, the combination being for artistic effect only.

secured, there being less chance for regular reflection of a large number of rays into a person's eyes and also less probability of there being dense shadows. Figures 6-10 illustrate the application of these ideas in present day systems of lighting. The spaces between the lines represent cones each of which contain the same number of rays, so that the intensity on the wall or floor may be estimated by the number of lines or cones directed to the same. The sectional line W-P represents the probable working-plane. The diagrams are entirely approximations but serve to indicate the relative distribution and diffusion with the different systems and at different locations in the room for the same system. In determining the amount of light contained in the reflected cone, the walls and ceiling should be considered as having efficiencies of from twenty to seventy per cent—twenty for brown or dark blue and seventy for clean flat white with cream and chrome yellow close the seconds at above sixty.

Each of the systems represented will be seen to have certain advantages. It has been the purpose of this article to explain the principles upon which the improvements suggested have been based. Because indirect lighting, as indicated in Fig. 10, is still somewhat of a mystery to the uninitiated, especially as regards efficiencies and costs, the writer hopes to discuss this system at some length in subsequent articles.

Every young man comes sooner or later upon a dilemma in which he is more or less drawn in opposite directions by his confidence on the one hand and timidity on the other; a desire to perform backed by the courage of his connections, but on the other hand resisted by his inability to see his way through in orderly progression to a desired end. This is about the time to show your nerve. Don't be dazed and baffled, but make a start. Use your wits and you will get somewhere, and if you cannot always see the end, it will constantly get nearer and plainer when you go as far as you can see and then see how far you can go.

WALTER C. KERR.

ACOUSTICS OF AUDITORIUMS

BY F. R. WATSON
Assistant Professor of Physics

The subject of architectural acoustics has come into prominence in recent years because of the increasing number of auditoriums with unsatisfactory acoustical conditions, and because of the growing demand on the part of the public that architects build halls free from these defects. The Auditorium at the University of Illinois presents an example of a hall where the acoustical properties are poor. The blame in this case cannot be laid entirely on the architect since the original plans were not carried out because of lack of funds. The interior of the hall was built very plain with almost no breaking up of the large areas of smooth wall surfaces, and, at first, the building had no carpets or curtains except the cocoa matting laid in the aisles. As a result the acoustics proved to be especially bad. Sounds persisted too long so that words uttered by a speaker in close succession lapped over, so to speak, and auditors had difficulty in understanding what was said. Also, echoes were set up because of the large dimensions of the building and form and position of the walls.

It is the purpose of this article to give an account of an investigation that has been carried on for several years to determine the causes of the unsatisfactory acoustical conditions, and also to find out, if possible, what steps to take to improve the defects. The results of the investigation show that both of these objects have been attained to a satisfactory degree. The undertaking is not yet completed, since the final changes to improve the acoustics have not been made. The conclusion of the matter is deferred at the present time because of the proposed installation of a pipe organ which will require some further experimentation. A later article giving details of the investigation and the final outcome will be published as a Bulletin of the University of Illinois Engineering Experiment Station.

Acoustical Properties of the Auditorium

The Auditorium presents many acoustical wonders. A watch ticking on the pulpit may be heard far away at a particular point in the gallery. In one position a whisper may be distinctly heard after it has traveled a distance of over 225 feet. When a speaker talks, the hall is filled with a reverberation of sound, while, in addition, each auditor, whatever be his position, is almost

sure to get an echo. The speaker himself has his words thrown back at him distinctly from no less than ten different directions. The chaotic condition may well be imagined.

METHODS OF CURE

The cure of such a case might well be considered hopeless, and, as a matter of fact, cases are on record where Auditoriums have actually been abandoned and used for other purposes because of the acoustical troubles. Fortunately, however, methods have been developed that allow even the worst cases to be improved. Before taking up these methods, it is of interest to consider the methods of cure prevalent in the popular mind,—namely, the use of wires

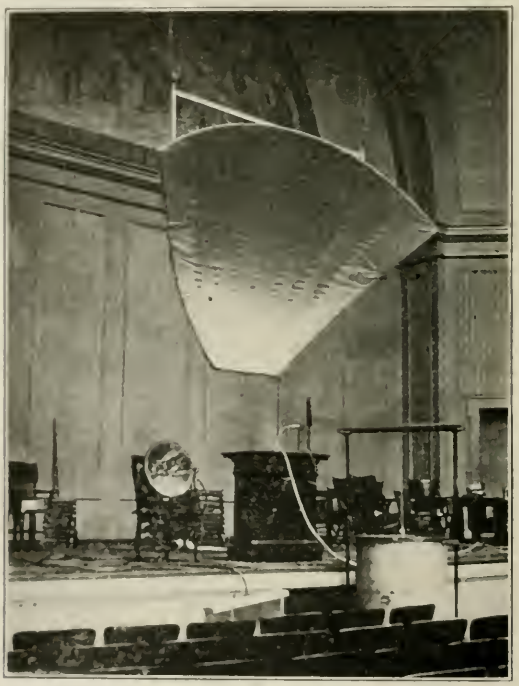


FIGURE 1

and sounding boards. As a matter of fact, wires are of practically no benefit, and sounding boards can be used with profit only in special cases. Wires stretched in a room scarcely affect the sound. They have much the same effect on sound waves that a fish line has on water waves. They do not present a great enough obstacle to make a disturbance. The author has visited a number of halls where wires have been installed, and has yet to find a case where

pronounced improvement has resulted[1]. In one case cited[2], five miles of wire were stretched in a hall without helping the acoustical conditions. It is curious that so erroneous a conception has grown up in the public mind when there is so little experimental basis to support it.

Sounding boards, on the other hand, have value in special cases. Fig. 1 shows a photograph of a sounding board used by the author in an investigation. This board produced a pronounced effect, and directed the sound in a way that could be anticipated. Its shape is that of a quarter section of a paraboloid of revolution. Earlier attempts with other boards were not so successful. Thus a flat board about 5 feet square placed obliquely over the head of the speaker produced but little effect. A canvas sheet, 12 x 20 feet, similarly placed, was but little better, although speakers said they could talk better under it than out in the open.

The parabolic reflector, however, gave pronounced results. Previous calculations indicated that the sound would be directed to a certain region, and this proved to be so. Auditors in this region protested vigorously against the echoes set up, but the rest of the audience was free from the usual annoyances. Such a reflector is limited in its usefulness, since it is readily seen that it can be used only for the case of a speaker who occupies a definite position. Any movement on his part takes him away from the focus of this paraboloid and the beneficial reflecting power of the board is diminished. Such a board would be of advantage in churches where the speaker occupies an elevated pulpit and is thus confined to a definite position.

One other suggestion set forth by the public in cases of poor acoustics is for architects to model auditoriums after those already built that have good acoustical properties. It does not follow that halls so modelled will be successful, since the materials used in construction are not the same year after year. For instance, a few years ago it was the custom to put plaster on wooden lath. Now-a-days the plan is to put hard plaster on wire lath—an entirely different form of construction. This latter arrangement gives hard, non-porous walls which absorb but little sound and thus aggravate the reverberation. Furthermore, a new hall usually is changed somewhat in form from the old one, and it is very likely that the changes will affect the acoustics.

We now turn to methods that are based on scientific work.

---

[1] Science, Vol. 35, page 833, 1912.

[2] Sabine, Architectural Quarterly of Harvard University, March, 1912.

Professor Sabine of Harvard University has developed a method for curing the reverberation in rooms. His method is well illustrated by the case of a house when vacant and when furnished. Everyone has doubtless observed that the hollow reverberations in an empty house disappear when the house is furnished. So in an auditorium, the reverberation is stopped when hangings, curtains and the like are installed in sufficient numbers. Professor Sabine carried on an interesting investigation for a number of years and found out a definite relation between the time of reverberation, the volume of the room and the absorbing power of different materials. The larger the room, the longer will the sound persist, while the greater the amount of absorbing material, the shorter will be the time of reverberation. He has determined the absorbing power of many substances so that an architect can not only cure a hall of poor acoustics, but he can calculate in advance of construction what the time of reverberation will be. In this connection, it is interesting to learn that an audience is one of the best absorbers of sound—a fortunate thing, since an audience is a necessary part of an entertainment in an auditorium. Furthermore, we learn that a woman absorbs more sound than a man. This is due not to their traditional ability to talk, but to the fact that they wear more clothes than a man.

Coming back to the investigation in the University Auditorium, it is seen that one very definite method was available to improve the acoustical conditions—namely, Sabine's plan of bringing in furnishings, curtains, etc. Now, while it was clear that this procedure would cure the reverberation, there was no assurance that it would also stop the echoes. So the author set to work to investigate this latter subject and spent several years on the problem.

Investigation of Echoes

Before an echo can be cured, it is necessary to find the reflecting surface that causes the echo. In the case of a man before a cliff, the case is easy. The man claps his hands, and an instant later gets the sound reflected from the cliff. This procedure was tried in the Auditorium, and plenty of echoes were obtained,—too many in fact—so that it was difficult to say from which wall each came. It became evident at once that it would be necessary to trace out the sound in one direction at a time and see what became of it. The difficulty was to find a suitable method to accomplish this result. A small clock backed by a reflector gave a small bundle of sound that could be directed. Considerable information was

gained in this way. Further data was obtained when a metronome giving more sound was used. This was put in a sound proof box and only a part of the sound allowed to escape through a hole that could be pointed in a definite direction. See Fig. 2.

The final solution came when an alternating arc light was used as the source of sound. This arc gave forth both light and a hissing sound, and these traveled off together. All an observer had to do was to note the position of the spot of light and he could "see" where the sound struck a wall. It was found that the main volume of sound was reflected so that the angle of incidence equalled the angle of reflection—the same as the law of

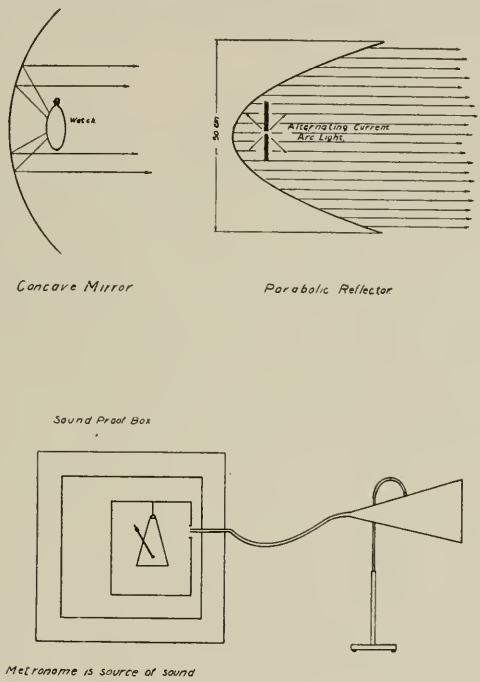


FIGURE 2

reflection of light. A systematic survey of the acoustics was then made by means of this arc light, and the main paths followed by the sound were definitely traced. Hangings were installed at certain points and the effect on the acoustics noted. Thus the acoustics were improved step by step by hanging curtains here and there as the progress of the survey indicated. There were a number of echoes that still remained, and it became evident that more radical steps should be taken to eliminate them. Four large canvas sheets were installed in the dome and the echoes were stopped

when the speaking was done from the center of the stage. The improvement was very marked. When a large audience was present, the reverberation also was reduced a satisfactory amount, and for the first time the acoustical conditions were passable.

The results thus obtained indicate in a general way what sort of permanent changes should be made to improve the acoustical conditions. The final installation of materials should conform to the color and architectural features of the Auditorium instead of being unsightly and haphazard as the hangings were for the investigation. Some further experiments are to be done concerning the installation of a pipe organ, and, as already stated, it is proposed to publish later a detailed article covering the whole investigation.

The engineer is likewise a member of society, from which he gets much and to which he owes much. Society is the relation of man to man. He gets from it not only the knowledge of life as it exists at present, but the history of its past development as it has left its impress on art, literature, science, and human experience. It alone has made possible the evolution of man from a lower to a higher state. In its rich soil alone the individual soul may germinate and expand into something larger and nobler. Man, and especially the engineer, cannot afford to withdraw from its stimulating influence.

FRANK H. CONSTANT.

SOME GENERAL CONSIDERATIONS WITH REGARD TO RAILWAY ORGANIZATION

ERNEST RITSON DEWSNUP
Professor of Railway Administration

In railway administration, as in other fields of activity, the type of organization is less important than the type of men who control it. A theoretically inferior organization may frequently be made to work admirably under the supervision of a man of force and ability, just as a superior one may fail to be successful in the hands of an individual lacking these qualities. Nevertheless a well-arranged organization is a most desirable thing—an aid to the work of administration of the highest importance. The desire for efficiency stultifies itself, however, when it leads to frequent disturbance and agitation of the existing organization, in the search for improvement. The restlessness of employees that invariably results from such a state of affairs is distinctly antagonistic to the highest efficiency. The mere fact that a railway has grown into a certain form of organization is a most powerful argument why it should be retained, to be combatted only by the clearest proofs of the net advantage to be gained by change. Such advice may be regarded as ultra-conservative, and yet many instances could be pointed out in which radical reforms, hastily inaugurated, have caused unquestionable mischief. Generally speaking, it may be taken as axiomatic that change should proceed by way of modification rather than by way of annihilation. The assimilation of new conditions is a somewhat slow process even with the most intelligent men, and a surfeit of such diet is apt to set up official indigestion. No organization can be understood, or fairly criticized, without reference to the history of its growth.

If an organization can be regarded as a function of its past environment, with equal propriety it may be looked upon as a function of the present. There is no type that is standard in all of its details for every combination of conditions. Comparisons of particular organizations have sometimes been lacking in point by reason of their failure to recognize the local conditions of adaptability. Because the divisional type of railway operating organization is the one that has shown itself best adapted to the requirements of the average American railway, it is not to be

inferred that there is no place anywhere for the departmental system or that, under other conditions, such as those in England, say, the departmental system may not be peculiarly suited to the needs of the railways of that country.

American railway organization has shown considerable elasticity. Much of the success achieved has been due to the fact that, in general, its history has been one of evolution, not of revolution. Violent changes of organization have been somewhat uncommon. The last conspicuous reform, that represented by the introduction of the unit or Hines system on the Harriman lines, is itself an example of the evolutionary process, for it may fairly be regarded as the logical development of the divisional system. With the increase in size of the unit of organization, however, certain problems of internal adjustment have become emphasized, and the brief consideration of these is the purpose of the present paper.

A question that is often before the heads of railway organizations is the one as to whether it is advisable for a railway to fill vacant official positions from among the officers of other railways.

The special conditions surrounding the appointments must determine what is to be done, but the conservative policy of making promotions from among those already in the service of the company concerned seems to have justified itself, in spite of some brilliant exceptions. The Pennsylvania Railroad is one of the most notable of American railways from all aspects of operation, and it seems to have maintained its premier position without drawing upon other railways to any large extent. Familiarity with local conditions and traditions might be set off against greater ability even, to say nothing of the encouragement to good work such promotion from within the forces of the company gives to men eligible for advancement. Of course, too great a sacrifice cannot be made to secure the advantage of local knowledge, and a road so unfortunate as to possess but mediocre ability in its subordinate officers must necessarily go outside in its own interests. But under normal conditions the failure to find suitable material for promotion within the company must be regarded as a reflection upon the conditions of service and training. And, be it said, neglect of attention to the proper training of both officers and men has cost American railways many millions of dollars. Under such circumstances, there is need of an infusion of new

blood and new ideas, and hence a justification of a search for men outside. Of course, where favoritism and nepotism have been allowed to dominate official appointments, the administration may be so weak or corrupt or both as to demand the unhesitating application of a severe pruning, making regrafting from other sources unavoidable but, fortunately, it is but rarely in these highly competitive days that conditions become so bad.

The general question of promotion is one full of difficulty. The principles of seniority and efficiency seem to be frequently in conflict. Yet a careful study of the problem would seem to indicate that, normally, promotion should and will go by seniority. The slavish following of the rule, however, is ridiculous. A railway is a profit-seeking undertaking, and must place the talent that is available to it in those positions in which it can secure the greatest efficiency of management. Accordingly, the rule of promotion by seniority must suffer exceptions, but the exceptions should be made only in cases where the very special fitness of the junior for the position is beyond doubt. In estimating fitness, mental agility or prepossessing personality should not be allowed to outweigh less seductive but more solid qualities. Hard-headed common sense and absolute reliability should be the indispensable prerequisites to consideration for any official position. No brilliance of speech or thought, no diploma or testimonial, can compensate for the absence of such virtues. A third fundamental qualification should be that of broad-mindedness, the ability to realize that there may be other tenable points of view than one's own, to perceive these and to allow for them according to their merits. Many difficulties of discipline, many official disagreements arise out of a lack in this particular: it would not be unduly extravagant to regard it as the most important factor of success in the management of men. It is surprising on how small an equipment of knowledge of human nature some men continue to carry responsibility. I take it for granted that broad-mindedness includes fair-mindedness. No official without fair-mindedness can long handle men successfully. Disobedience and insubordination, inefficiency and extravagance are the results inevitably reaped by such an individual. Better severity with justice than graciousness with partiality. As in the case of the school-boy who remarked of the famous school-master, Doctor Temple: "He is a beast, but a just beast," impartiality will de-

mand and secure from employees respect, in spite of rigorous discipline.

A severe and unapproachable manner, however, is a serious disqualification to a railway officer, and should be got rid of. Not that the division superintendent, or other official, should be Tom, Dick, or Harry, to those for whose efficient discharge of duty he is responsible. A certain amount of pride of position is allowable and desirable. But it is possible to show bonhomie without sacrifice of proper dignity, and the combination of the two is mighty effective in drawing forth from subordinates their sincerest efforts. A whole-hearted support is secured that would otherwise be lacking. Subordinate officers feel that they are not servants but appreciated colleagues. In days gone by, one of the proudest boasts of railway officialdom in America has been its accessibility. Nowadays, I am afraid that this has been seriously diminished. It is almost as difficult to penetrate to some officials as to the Czar of all the Russians. The former has its evils, but they are in no way comparable with those of the latter. In some instances this extends even to the relations between the chief of a department and his lieutenants.

A modified form of the same evil results from the tendency of some departmental chiefs to overburden themselves with detail. The eye of the master should be everywhere, but it does not follow that his hand should. The efficient chief reveals his skill, first, in selecting capable assistants, and, secondly, in leaving them alone to do their assigned work. This principle of local responsibility is an extremely important one. Its application results in better work on the part of subordinate officers, who are given a chance to use their judgment, thereby developing initiative and self-reliance. While there must be a certain degree of uniformity in standards, in accordance with which all must work for the good of the concern, there is still left a wide field in which methods may be left to those charged with the immediate supervision of the work so long as the proper results are secured. Relieved of this detail work, the departmental head has time to attend to his own proper duties, viz., to secure harmonious cooperation between the forces he controls, to consider the general policy of his department and to discuss the same with his colleague—assistants, and so far as practicable to study the working of corresponding departments elsewhere and all other relevant

matters that may not be embraced within the daily routine. Some officers seem to think that their duties leave them no possible opportunity of study. This may be so in some unfortunate instances but, as already indicated, it is more often than not due to the inability of the officer himself either to secure the right men as assistants, or to credit them with the capacity of handling their own duties, an attitude provocative of distrust and discontent which readily translate themselves into waste and extravagance.

In visiting the office of an esteemed friend, who is the vice-president in charge of operation of one of the large railway systems of the country, I have often been struck by the freedom of his table from documentary litter. Here is a man at the head of a whole army of employees who can find time to consider policies, consult with his lieutenants, discharge the thousand-and-one duties attaching to his responsible position, and he does it all with a clear table. A clear table has come to identify itself in my mind with business efficiency of the highest kind. But it is impossible of attainment except where the principle of local responsibility is understood and properly applied.

Connected with this subject is that of undue formalism between officers, or, in a familiar phrase, red tape. There is a great deal of difference in this respect between different departments and different railways, but I am inclined to think that not a few departments are cursed with a superabundance of interofficial letter writing. Official letter writing is a necessary evil, and like all evils it may easily become rampant. Profuse letter writing easily develops misunderstandings, holds officers off from one another, consumes time and money. Anything that will conduce to the cutting of this red tape is to be welcomed, and it is one of the hopeful things about the new plan of divisional organization, introduced by the Harriman lines in the beginning of 1909, that it promises to reduce the number of letters written "about 40 to 50 per cent." There is obviously room for reform.

But finally, let no student pursue an education alone for its material ends. He should strive to be not only a trained specialist but also an educated man, and some day, if not now, he will see that the latter is as desirable as the former.

IRA O. BAKER.

THE DETERMINATION OF STRESSES IN STEEL STRUCTURES BY THE USE OF THE BERRY STRAIN GAGE

BY G. P. BOOMSLITER
Instructor in Theoretical and Applied Mechanics

It is a well known law of mechanics that a bar of steel is deformed by the application of a force to it, the deformation within certain limits being proportional to the stress set up by the load. The relation between the deformation and the stress due to an axial load is expressed by the equation $S = E\frac{e}{l}$, where S is the unit-stress set up in the material, E is the modulus of elasticity of the material, e is the elongation or shortening in a length l. From this it is clear that, if upon the application of a load to a framework, the change in a definite length of one of its members can be found, the unit-stress in that member due to the load may be determined, provided that the modulus of elasticity of the material is known.

The Berry strain gage is an apparatus for the exact measurement of such changes in length. It consists of a metal frame, with two pointed steel legs projecting at right angles from the ends and on the same side of the framework. One of them is rigidly attached to the framework; the other pivoted to it. Attached to the pivoted leg is a multiplying lever which extends back within the framework. In contact with the end of this lever is an Ames dial micrometer which records to $\frac{1}{1000}$ of an inch the motion of the end of the lever. As the multiplying lever multiplies the motion at the end of the pivoted leg by 5, the dial records this motion to $\frac{1}{5000}$ inch. This, in a 10 inch gage length, corresponds very closely to a change in stress of 600 lb. per sq. in.

Fig. 1. is a sketch of the Illinois type of Berry strain gage shown in use in testing reinforcing bars in concrete: B is the end of the pivoted leg, D is the pivot, and C is the end of the multiplying lever, which is shown in dotted outline. This is the type of instrument used in the tests mentioned in this article. The length DC is approximately equal to 5 times the length of BD so that the motion of the point C is about 5 times the motion of the point B.

Small holes are bored in the member whose stress is to be measured, so that the points on the projecting legs may set into them.

The figure shows the points of the strain gage set into the holes in a steel reinforcing bar. The Ames dial is read when the points are so set. The load is applied, the points are again set into

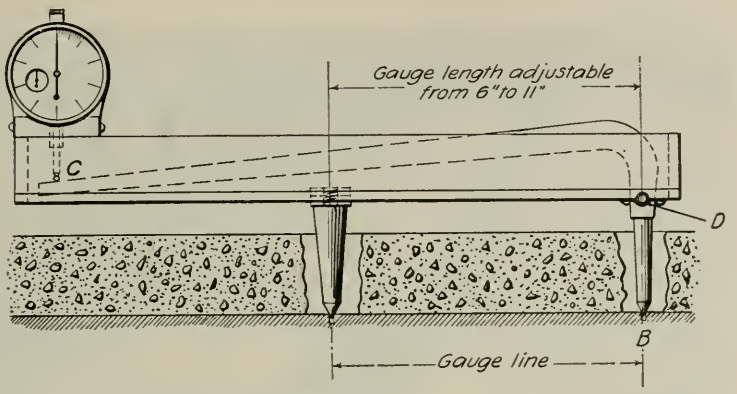


FIGURE 1

the holes, and the dial is again read. The difference in these readings will give the change in the length between holes. This distance between holes is called a gage length. If these readings were taken very closely together, the change in length would be entirely due to the stress set up in the member. Since a considerable interval must elapse between these readings, a change in temperature would change the gage length. To measure this temperature change, a gage length of equal dimension is established on a piece of steel which will not be subjected to stress and the dial is read on it when the first and the second series of readings are taken, and the temperature correction obtained therefrom. Descriptions and cuts of the various types of strain gages may be found in an article written by Prof. H. F. Moore and W. A. Slater and read before the International Society for Testing Materials at its last annual meeting. It may be found in the published proceedings of that Society.

The Berry strain gage has been used with marked success in determining the stresses in the concrete and and in the reinforcing steel of reinforced concrete structures. Bulletin #64 of the Engineering Experiment Station describes several successful tests of this kind on buildings.

The successful use of the strain gage on reinforced concrete buildings suggested its use for determining the dead load stresses in the steel arches of the new University Armory. Contrary to previous custom, where a test entailed a costly loading and un-

loading of the tested structure, plans were made to perform the test with little or no trouble to the erecting force, and with no preparation except the necessary preparation of the gage holes.

Taking Readings on Erected Steel Arches, University Armory

Accordingly, while the material was still on the cars awaiting transfer to the Armory site, about 100-10 inch gage lines were established in 4 panels of one of the arches and several sets of initial readings were taken, care being exercised to take simultaneous readings on a steel standard bar. After the erection of the steelwork, other sets of observations were taken together with simultaneous readings of the standard bar. There still remains to be taken at this writing, the observations for stress with the roof covering in place, and observations under wind or snow load.

Several causes have thus far rendered the tests only partially successful, among them being the indeterminate effect of temperature stresses, weather conditions during the preparation of the test holes, Illinois mud, and particularly, the low stresses which exist in the structure under dead load. It is this last feature which will make the wholly successful determination of the dead load stresses in steel structures extremely difficult, for a possible error of more than 600 lb. per sq. in. in a total stress of 1500 lb.

per sq. in., say, is a disconcertingly large percentage of the whole. The use of a longer gage length, which reduces the error in proportion to its increase over 10 inches may be the solution of this problem.

While this experiment was under way, an opportunity arose to use the strain gage for testing the steel bridge by which the Illinois Central Railroad crosses the Kankakee River at Kankakee, Ill. This test differed from the test on the Armory, first in the fact that the distance between the extensometer points was 60 inches instead of 10 inches, thereby reducing the probable error in the unit stress to about 100 lb. per sq. in. and second, that a very considerable load in the form of a Mikado engine, two coal cars and a caboose could be quickly applied and removed. Under these circumstances, it was not deemed necessary to use a standard bar to correct for change of temperature, but two sets of readings were taken of the unloaded bridge, one immediately before and another immediately after the load was applied, and any change in these was assumed to be due to temperature change. This test in which top and bottom chords, hangers and diagonals were tested, was completely successful; the theoretical and actual stresses being found in very close agreement.

A new and important use for the strain gage was brought out this summer in two tests on railroad structures in Chicago. One was on a swing bridge of a steam railroad. It had suffered bent eye bars and other damage through a derailment. Tests on the damaged bars showed conclusively that the structure was in no danger even through the application of the heaviest loads, to which it might be subjected. The greatest stress observed in the critical part of the structure when the road's heaviest engine drawing a loaded train passed over the bridge was less than 11,000 lbs. per sq. in. This stress was verified by the approximate agreement between the average stress set up in the similar members of the two trusses composing the bridge. The other was on a panel of an elevated railroad structure in which a flat bar was used to take counter stresses in compression and in which other members were supposed to be very highly stressed. Strain gage measurements under a pair of motor cars again showed that it was designed for, and the stresses in the other members were safe even under conditions of maximum load. Again, as before, readings on similar bars on the two trusses composing the bridge were so nearly alike as to verify the conclusion as to safety.

The tests made so far show that the strain gage is of practical value in determining the safety of steel structures. It remains for other tests to prove its use as an aid in the solution of the theoretical and practical problems which still remain to the investigator of stresses in steel structures.

The time is at hand, when the engineer should be so educated as to appreciate the artistic possibilities in his product, and to exhibit æsthetic sense in design. When the great engineering feats of today become the ordinary products of tomorrow, the public will demand beauty of design, as well as rigidity and utility of construction and installation. And when the demand is made the men who have finished an A. B. course in the university, followed by a full engineering course, will occupy first positions because of the important cultural training they possess.

ARTHUR C. SCOTT.

STANDARDS OF STUDY

A. E.

The university student of this country has often been criticized for lack of interest in the vital problems of life. The accusation is brought against him that he does not think seriously and that he has few well developed convictions. Upon one subject however, every student has at some time meditated and as a result of some reflection he has arrived at a conclusion. And the peculiarity about the conclusions is that there is almost complete unanimity. The problem is the relation of high scholarship to ability as a student, and the conclusion (in the phraseology of the Philosophy 1 student) that there is no universal connection. The high scholarship man is not always a capable student. Unfortunately the meditator breaks off his philosophical trend of thought at this point (possibly because the thought is so soothing). He is not Socratic enough in his speculations to ask, "Are all capable students who apply themselves high scholarship men?" Neglecting a few isolated cases in which there may be enmity between teacher and student, this question may be answered in the affirmative. Capacity, then, shows itself in scholarship unless through indifference or lassitude the gifted man neglects his legitimate purpose in attending the university, in which case he would do more good for himself and his alma mater if he would forfeit his opportunities here to a more seriously minded person. Let us apply the gage of scholarship to ourselves.

Can the faculty for study or facility in the mental processes of reasoning be cultivated? Yes, with one proviso—the faculty for thinking must be present as a germ. The need for a native or inborn endowment to think is emphasized by Doctor Dewey of Columbia University, "A being who could not think without training, could never be trained to think; one may learn to think *well* but not to *think*." Assuming that this latent gift is present, how can it be developed?

An answer to this demands an understanding of the mental characteristics of the capable student. In the pursuit of the rationalistic studies common in the curriculum of an engineering college such as physics, mathematics and mechanics, the analytical and logical mind finds an easy path, while the mind of the memorizer, sensitive only to impressions upon which it does not react, finds these studies very difficult. The capable student is marked

by a faculty for drawing inferences and arriving at conclusions through consecutive thinking often without such media as the interpolations of a text-book or the equations written by an instructor on the black board. To the extent that we reflect and weigh suggestions are we capable students.

How then, shall mental power be obtained? A general, before proceeding to an attack, first considers the gains resulting from a possible victory and whether they warrant the costs. Having decided upon this, he studies the topography of the country to determine the best point of attack and the most feasible road to a desired vantage point. So in studying, there are profit and loss, angles of approach and difficult passageways. The soldier follows the flag which is directed by the general, the student must be guided by his rules or standards. The former may win political power, the latter power of intellect.

Before starting to put into effect the annual resolution, "I am going to study this year" let us examine the costs of the kind of study under consideration. Reflective thinking involves exhaustive application and a mental discomfiture that soon drives many away from their resolutions. Unless we coördinate a determination to suffer the costs involved we shall not "live up to" our resolutions. In this connection might be mentioned a habit that is quite as deleterious to successful study as a refusal to undergo the trials of mental labor, namely the disposition to seek the most comfortable position while studying, such as that of resting the head on the palm of the hand with the elbow on the table, sliding down into the seat with the feet stretched out in front, and an inclination to pick out the rocking chair or to recline in a Morris chair. The thinker must be more or less of a stoic.

This step made, the attitude of mind best suited to the attainment of the powers we desire must be decided upon. Shall it be a disposition to accept or reject, passively to absorb as true what is heard or read, or to doubt? "The writer is an authority, must I believe him?" To doubt an assertion made by an authority may sound impertinent, but how can it be true for *us* unless *we* can verify it? In the abstract, the statement may stand for an actual or real relation, but *I* cannot be certain of its validity unless I can show it to bear a definite relation to facts already a part of my mental structure with which I find it to harmonize, or until through a process of analysis I can show it to be the logical results of what I know to be true. What right have I to accept

a statement as true if I cannot fix it? Unless a new relation can be associated with past experience it is meaningless. This applies, of course, only to the exact sciences, and not to such subjects as history, grammar, or a language, the purely descriptive or informational studies in which the aim is centered on a thorough acquaintance of the facts as presented by a particular author. Mechanics, on the other hand, although founded upon three simple laws, is a very complex science in which each new theorem is built upon previous theorems and is a logical result of these, the whole forming an intricate but closely connected structure. Unless the critical, cautious, and doubting attitude controls the mind we are apt to drift along at an easy indifferent pace continually accepting but never understanding.

Closely related to the will to believe is the unwillingness of many men to exert themselves to an investigation. This mental servility is illustrated nowhere better than in the common habit of memorizing formulas instead of trying, first to get a clear conception of the relation between the constituent members of the formula, and then of tracing a path from the more fundamental relations previously established to the special case under consideration. The best students make it a special point never to remember the statement of a theorem as a formula unless they are positive of being able to develop it. The tendency to seek the easiest path is also shown in the familiar classroom answer, "The book says so." Let us note this and similar expressions, for they reveal a very weak mental constitution. Unless the "why" can be brought forth we shall always be at loss when questioned, and can never be certain of our footing.

If a proof be demanded for every new theorem how shall we conduct the inquiry? The answer to this question is quite beyond the scope of this article. The chapter on Reasoning in the second volume of William James's Psychology may be studied for this purpose. For a comprehensive analysis John Dewey's "How We Think" may be referred to. A few general remarks may, however, not be amiss here. Of primary importance to the reflective mind is wealth of past experience to furnish suggestions to clarify new and perplexing situations. The experience may be in the form of facts carefully distinguished as the propositions in geometry or the fundamental laws in physics. The necessity for a thorough mastery of the basic mathematics cannot be emphasized too strongly. Reviewing is valuable mental exercise since it not only fixes the many theorems and corollaries more

thoroughly in the mind but it also outlines and differentiates each one from every other one and so makes them stand out in plainer view when they may be needed to support or to lead to a new proposition. A little time spent in reviewing a subject long after it has been covered in school is time well spent since such study often reveals contrasts and similarities not at all evident when the subject was formally studied. Another significant factor in the function of proof is a proper regulation of the conditions under which thinking occurs. In choosing from a multitude of suggestions that may spring up in explanation of a difficulty it is necessary that we continually guard against allowing facts that corroborate a previous or favorable belief to supplant those that properly belong in the case under consideration. A habit of discriminating between the more and the less important should be cultivated. The practice of underlining important passages or words is valuable for this purpose.

Let us be self-reliant in study. Let us resolve not to disturb our room-mate, or the senior in the house, or the instructor in his office. This is another mark of a disposition to shirk the mental labors of inquiry. Locke in his Essay Concerning Human Understanding long ago noted that this dependence upon authority kept more people in ignorance or error than all the other causes of bad thinking together. Professors can often save us much troublesome thinking by suggesting a single word, but we can not be better situated for the assistance given, as our faculty for thinking is not strengthened by being relieved from the trouble of an investigation. Self-suppression and self-distrust have never brought forth men of firm character and mental vigor. Passive absorption without reaction and objection are great drawbacks to mental progress. Likewise an unwillingness to plow down into the depths of the hard soil of the mathematics and sciences can never gain for us wealth of knowledge and power.

To summarize: Indifference, carelessness, listlessness, mental lassitude, and a disposition to absorb without question or hesitation mark the intellectually indolent and incapable student. A tentative attitude toward all knowledge, remembering that perfect reliability is attached to very little knowledge, "that highest wisdom represents only a rough approximation to the truth" is the soundest and safest attitude. A tendency to doubt and examine even the statements made by superiors in knowledge, at the same time keeping the mind ever open to suggestions, is a guaran-

tee that thinking will not go astray. This with deliberation in decision and constancy in conviction are indications of healthy mental processes. And finally let us bear in mind that self-confidence and self-control with a determination to bear the costs of application are characteristics of the ideal man who, in the words of F. M. McMurry, is "neither afraid, ashamed nor servile, but dares realize himself rather than imitate others, who in short lives naturally and honestly."

The foundation of healthy life in the state is necessarily composed of the men who do the actual productive work of the country. Among these producers the engineer is preëminent. Without him in the complex commercial life at present, capital would lie idle, colossal manufactures would shrink to individual industries, the development of resources would cease, the earth would no longer contribute as now to the wealth of nations, and society might eventually relapse into the relation of the feudal baron and his retainers of the middle ages.

HENRY S. CARHART.

HOW WE STUDY

The following series of short articles represents an attempt to discover the best methods of study. The articles come from some of the most successful students in the Engineering College, most of whom find their names in the list of the 20 highest scholarship men in the University.—*Editor.*

A SUGGESTION FOR STUDY

Nearly every man who comes to college has the idea that to study means to ponder long and diligently over the pages of some text-book. It is fortunate that we have these books, for they are written by men who are well versed in the subject with which they deal, but are they meant to be, or can they be more than mere outlines, a series of statements of the fundamental principles of the science with but comparatively little elaboration? If the text-book is no more than this, and, I believe you will find that it is not, then you must do a large amount of independent thinking. Such thinking constitutes real study.

If you are taking Trigonometry, try this experiment. Learn the definitions of the functions of an angle; then lay aside the book and see what you can do with them. With the aid of a few old principles of Geometry, you will soon be able to develop relations between the functions and to solve right triangles. Every method and every proof that you will have used will be, in a sense, your own invention, and it will not, therefore, be readily forgotten. It may be necessary to refer to your book occasionally, but as you progress the text-book will become merely a reference volume, a source of suggestions for further research.

This method may not be applicable to every study which you pursue. It may be necessary to revise it, improve it, or even reject it entirely, but at least give it a trial. There is very little to be lost by such an experiment and always something to be gained, for even though the use of such a method may not be of immediate assistance, it will eventually give you self-confidence and the ability to reason clearly, logically, and, above all, independently.

R. W. Owens, '14.

EFFICIENCY THROUGH TIMING AND METHOD

An engineering student must study with some efficiency; his time is well taken up, and the only alternative is failure. So it is

a problem, to new students in particular, to secure this efficiency. The writer feels that much of his time is still wasted, but his efforts to secure effective study have resulted in a few methods that may be of interest to other engineering students.

The primary effort has been always toward securing concentration. It is believed the greatest thief of study time is wandering of the mind from the subject at hand. The writer has found that the most potent way to keep the mind "within bounds" is to set a reasonable time limit upon each study task at its beginning, and to keep somewhat in mind throughout the preparation an imaginary appointment, say, at the end of the allotted interval and previous to which the subject *must* be prepared. Everyone knows that cases where such appointments are real instead of imaginary often bring out one's greatest concentrative powers.

Besides efforts toward concentration, the writer practices a few special methods in attacking certain particular subjects. In studying mathematics and mechanics, for example, the stress is always laid upon grasping *methods* of procedure, not upon learning theorems word for word, nor upon solving large numbers of problems by means of a formula whose derivation is hazy. In later days theorems and formulas may be forgotten, but if the fundamental methods have been mastered, the whole science can be built up, if need be, out of hand. It may be added that the writer has found when an assignment contains both theory and problems to be worked but not handed in that preparation of the complete assignment leaves nothing to be learned, or to hold one's interest, in the recitation. Wherefore the theory is studied well, but time is spent on two or three problems only; the application of the theory is readily mastered by paying close attention to board work in class and the time spent in recitation is thus deducted from that required for preparation.

C. W. Lincoln, M. E., '15.

ON THE BEST TIME AND PLACE FOR STUDY

After making a careful analysis of the methods of study which I use, it is impossible to incorporate them into what might be termed a system. I have attempted a few times to follow carefully drawn up schedules such as freshmen are advised to follow. From my experience I have come to think that all such schedules must fail, for they do not yield themselves to the ever changing

dispositions of the student. There are a few rules that I try to follow. They are not part of any schedule or system designed to insure the preparation of studies or to secure a proper balance between recreation and study, although both these objects are attained through their observance. They are the outgrowth of my endeavors to secure the greatest value for the time spent in study. These rules may be summed up in saying that the most successful study is largely a matter of choosing a proper time and a proper place for the preparation of each subject. I have found that to study a subject in the same room in which the recitations are held helps to impress details of the lesson more firmly upon the mind. When I leave the room, I can dismiss all thoughts of that subject and still feel assured that when I return to that room I shall be able to recall those details distinctly. On the other hand, if I attempt to study three or four subjects in a single evening at home, in other words to "cram," I come to class with a mind confused with a jumble of principles, laws, and equations which I am unable to separate and identify. This plan gives me the added advantage that I am able thereby to make profitable use of time that would otherwise be spent in going from and to classes.

For these reasons I do most of my studying in the vacant hours of the mornings and afternoons and in the earlier hours of the nights. The later hours of the nights are reserved for written work. I find that the little manual labor which writing and drawing involve is an excellent preventive of drowsiness and, for this reason, enables me to make the most effective use of those hours. I rarely permit my studies to keep me up later than my usual time for retiring. If a study has been neglected rather than stay up until midnight to finish the preparation of the assignments for the day, I prefer to retire at an hour that assures me sufficient rest to be fit the next day to supplement with the class room work the little study that I did accomplish. It has been my sad experience that whenever I kept very late hours for the sake of my studies, the next day found me feeling drowsy, unfit, and exceedingly prone to make those small but disastrous mistakes which make a fellow doubt that he was awake when he made them, and which, in the end, really determine one's class standing.

MAX HOLMBURGER, '15.

STUDYING MATHEMATICS

Whenever I tackle a lesson in "math" there are three points which I always try to keep in mind. In the first place, I always see to it that I understand the preceding lessons; in the second place, I try to become as interested in what I am studying; and lastly, I attack the lesson with a spirit of competition. In mathematics, one lesson depends to a great extent upon the preceding ones; without having understood the previous lessons one can hardly hope to understand the one in hand. Therefore, I always understand (or think I do) the lessons leading up to the present one. In the second place, I can study much more efficiently when I have an interesting subject. This being the case, I become as absorbed as possible in the lesson. Whenever a problem is worked out in the text, for the student's benefit, I am interested in noting exactly how and why it was done in the manner shown. However, my interest is mostly kept up by the spirit of competition with which I attack the lesson. I tell myself that either I am to master the problems or they are to master me. Many times, when the text has worked out a problem for us, I try to solve it before finding out how it has been solved in the book. I try to get ahead of the text every way possible; and whenever I find a mistake in the printing or a wrong answer I take it as a personal victory over the old enemy. I never cease working on a problem until I have solved it to my satisfaction. A short time ago we had a problem in calculus which I thought had me "stumped." I had tried it from every possible angle of attack but could not get the desired answer. I had almost given the problem up in despair when I happened to think that I would then be conquered by the problem instead of conquering it. Then and there I determined that I should win even if I had to sit up all night to do so. With this determination I again began the problem and it was not five minutes later before I had solved it to my complete satisfaction. With the few things mentioned above kept in mind, I find very little difficulty in learning the average lesson in mathematics.

Maurice C. Johnson, '16.

ON A QUIET ROOM AND CULTIVATING CONCENTRATION

To study properly, a quiet room is a prime requisite. When I first came to this University, I was with a farmer's son whom I believed to be a studious boy and one who would

start me off correctly. But when we started to look for a room, he remarked that he wanted to go where there was a "jolly bunch." Well, this "jolly bunch" idea did not appeal to me, so when I struck a house with a good scholastic record, this man and I parted company. The result was that he formed a "jolly bunch" and his grades were always hanging by the margin. Did you pick a "jolly bunch"?

Sometimes you may be in a quiet house with a group of studious boys, but even here you will often deceive yourself. Your roommate may have a loquacious disposition. The two of you may start an evening's study, but how often does the roommate interrupt you with some question far from the subject you are studying? Or how often do you likewise interrupt him? The best thing for you to do is to stop it yourself and see that he does too.

Most important of all, however, is mental concentration. This is a faculty that is rarely developed by many, but which can be cultivated by all with a little effort. When you sit down to study algebra, forget the language; when you study chemistry, forget calculus. But keep your mind on what you are studying. Mental concentration may be practiced when you are trying to listen to dry or uninteresting lectures, or perhaps a more beneficial method is to stick to some problem you are caught on, and thing of nothing else till you get it. In this way a faculty may be developed which may be a benefit throughout your life.

E. A. WILLIFORD, '15.

KEEPING NOTES

In this allotted space, I shall endeavor to indicate the one thing which, I think, has been most helpful to me as a student. This is systematic note keeping. By note keeping, I do not refer so much to notes kept in the classroom as to notes kept at home during study hours. With the full schedule of the engineering student, it is often impossible, on account of a lack of time, to read an assigned lesson more than once, yet there are a few essential points which can not be fully comprehended and fixed in mind by one reading. Now during the first reading, it requires but a few minutes more time to jot down in a note book all of the important facts and principles in the lesson. In this way a dozen pages of the text can be condensed into a single page of notes, and a page of notes can be reviewed almost as quickly as one of the text. By keeping such a system of notes each day, I have, finally, a

complete skeleton outline of all the work covered in the course. Then with the aid of this outline, it is convenient and very beneficial to make a hasty survey of the work at the end of each week. I have found by following this method of study that the awful task of "boning for exams" is, to a great extent, eliminated.

I. R. Cline, C. E., '15.

STUDYING CALCULUS

Let us assume that the instructor has told us about the purpose of the course and that we are to study certain kinds of limits, limits of indeterminate forms, such as $\frac{0}{0}$, etc., then derivatives, and by means of them to solve problems of rates of change, etc. We start out with limits and review what we have had in Algebra. Then we come to derivatives proper. We find that, analytically, they are limits of the form

$$\lim_{\Delta x \doteq 0} \frac{f(x + \Delta x) - f x}{\Delta x} \left\{ \begin{array}{l} \text{where } f(x) \text{ is continuous} \\ \text{and single valued within the} \\ \text{range considered.} \end{array} \right\}.$$

Now, we ask ourselves, what is a derivative?

We give a geometric interpretation of the function f (x) and its derivative and find that the derivative is the slope of the tangent to the curve. Now we see what derivatives are and come to the problems of derivatives of functions. Well, first we come to the problem derivative of a sum and here I close my book and try by any method I know to solve the problem and find that the derivative of a sum equals the sum of the derivatives. This method works nicely until I come to the logarithms. Now I find that I have to take the derivative of logx. Well I close my book and try this and that, and can not solve the problem. Now see what this does for me. I tried the problem and could not do it. The author tried it and did it. I see that I have something to discover in the author's proof and when I open the book I am sure to get everything he says. I see the necessity for the introduction of the limit:

$$\underset{x = \infty}{L} \left\{ 1 + \frac{1}{x} \right\}^{x} = e, \text{ etc.}$$

Now, by attempting to work the problem myself I find out what I have to do and try to do it. Not being successful, I open the

book and get some suggestions from the instructor and close the book and try to solve the problem and when I do get it, I know it. I know why I do this and that. I do not need to say that the author says so, and that's why. I do not take his word for it. I want to see for myself. I work out everything that he says "comes out so if worked out." If I do not follow the instructor or author easily, I review the book again until I do, and I cannot see how any trouble can ensue.

A few sayings that help in studying.

"See what you have to do and go right ahead and do it."

"Never say a course is difficult. Say it is easy. Half the battle is won by confidence in one's self."

E. R. HATOWSKI '14.

STUDYING DESCRIPTIVE GEOMETRY

I have found that the greatest difficulty, encountered by the student in Descriptive Geometry, is his inability to form an accurate picture in his mind of the construction of the problem. In the text book, it is necessary to represent a plane by showing the lines of its intersection with the reference planes, and lines and points by their projections upon these reference planes. Before you can master Descriptive Geometry you must be able, from these lines and traces to form an accurate picture in your mind of these lines and planes as they stand in space.

A method which I found very useful was this: I first constructed, from heavy cardboard, a set of reference planes. At spare moments I "played" with this model—holding a pencil in different positions in the various quadrants, and drawing its projections on the H and V planes—then flattening the planes together to see how these projections would appear if printed on a page of the text book.

Advancing into planes, I used auxiliary pieces of cardboard, held at various inclinations in the different quadrants—drawing their traces on the references planes.

With a little practice of this sort, it will not be long until, when you look at a figure in the text, you will see a line standing out in space in the third quadrant, or a plane perpendicular to the H and inclined to the V plane, instead of seeing merely the projections of such a line, or the traces of such a plane. When you are able to do this, you have conquered one of the greatest difficulties of Descriptive Geometry.

One other thing: The analyses in the text book embody the fundamental principles of Descriptive Geometry. Learn them. Become familiar with them, and with their application. Then, when you meet a problem in the drafting room, you may take one after another of these analyses from your stock, fit them together step by step, as you would the pieces of a puzzle picture, building them into a complete solution.

Practice originality. Many of the problems have no "cut and dried" method of solution. Go back to your stock of analyses, and see in how many different ways you can fit them together to obtain the solution. When you do this, Descriptive Geometry becomes an interesting and delightful study.

J. C. Palmer '14.

ON SLEEP AND WORRYING

There are a few principles that I have always tried to follow in studying. Perhaps the foremost of these is the one dealing with the regularity of sleep. I have always found, and it is a well known fact, that one can do much better work in his classes if he has had the necessary amount of sleep the night previous. Some people argue that a fellow should be absolutely prepared before he goes to his classes regardless of the amount of time it may take for such preparation. It is my idea, though, that a fellow is better off if he cuts down the time he puts on his studies and gets a sufficient amount of sleep. How much sleep is a question for each one to decide for himself. The division of a fellow's time between pleasure, work, and sleep is a differential equation which has to be set up separately for each individual.

What a fellow gets out of a book usually needs some explanation. It is in the class rooms that this explanation is given. And a fellow with a drowsy mind is not the fellow to comprehend these interpretations.

Another principle of mine is to give the brain a change of thought, to give it more than one thing to think about. To let it continue along the same channel is to wear it out. For such a change I would advocate an interest in some university activity, or activities, which is better. There are numerous ways in which a fellow may engage himself, which space will not permit me to mention.

Such practises as writing down an equation to see how it looks in one's own hand writing and a card-index system of notes are very helpful to the memory.

Taking an optimistic view of the whole situation, I think that a good principle is to change the common expression "I should worry" to "Why worry?" Worrying will not get a fellow any place but the hospital. You can not change any state of affairs by worrying. It will place a load upon the mind that will hinder you from clear thinking. Spend what time you do in worrying, in study and you will find the powers of obtaining knowledge far easier. BARRETT ROGERS, C. E. '15.

AIDS TO STUDYING

It is a regrettable fact that many men come to college with little or no idea of the right way to study, and as a consequence they find this first year here much more difficult than it should be. Much of the advice given on this subject is of such a general nature and so full of bombastic and vague phrases that they are of small practical value. It is my object, however, to give the reader something more definite in the way of advice, and to this end I will describe some of the devices which I have found of considerable assistance in studying.

The first of these devices is the emphasizing of important words and passages in the text by underlining them. In this way the vital parts of an assignment may be strongly emphasized at the time they are gone over, and a clear conception of them impressed on the memory. It will be found a great deal easier to remember the comparatively few underlined parts than to attempt to retain an accurate mental picture of the whole text. This will also be of great value in reviewing for quizzes and examinations, because the fundamental principles and important points may be gleaned in a short time by reading carefully these passages.

Another thing I have found of real help in the study of such subjects as mathematics, mechanics, etc., is the working of problems. Often where the text has been hazy and hard to grasp, working a few problems has been found to clear up the doubtful parts wonderfully. It is always advisable to work as many of the problems connected with the work as possible, even if the text is clear, because it tends to fix more firmly in the mind the principles involved, and the applications of those principles. It is not usually essential to work all the problems given in the text, but only enough to give one a thorough understanding of the theories and their applications. In fact, it is just as essential to get a firm grasp on the practical applications as it is to learn the theories.

In an article of this brevity, the subject can not be covered thoroughly, nor gone into deeply. But it is hoped that these few suggestions, while brief, may be of some benefit to those who have experienced difficulty in studying.

H. R. Tear, '14.

STUDYING T & A. M. 7

The most useful thing I found in solving problems in T. and A. M. 7 was the free body diagram. This done, the most difficult truss and crane problems encountered soon dwindle down to a point where it is only a matter of adding up the forces before the answer stares you in the face. I attempted never to let the problems pile up and then to get them all done in one day, but I always did each problem as it was assigned. I also found that in a two hour "off" period in the morning I could well afford to spend fifteen or twenty minutes clearing up some of the hazy points left from the night before. With a fair knowledge of first semester Physics, no engineer should have much trouble with T. and A. M. 7.

H. E. Austin, '15.

Science and engineering cannot be picked up from popular expressions on the rambling thin attractive description of novelties, but only from the study of the fundamental principles. Therefore read books. Study principles, not novelties. Think theory and work practice. Turn to real sources not to the tricks of words and platitudes which so often catch one's fancy and in a superficial way lead one to notions rather than to logic.

Walter C. Kerr.

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EDITORIAL

STUDIOUS ACTIVITIES VERSUS STUDENT ACTIVITIES

Upperclassmen commonly experience an unexplainable fall of scholastic standing from that maintained during the first two years at the university. The cause for this cannot be found in more difficult subjects nor in more hours on the study programme, since few students carry as heavy a schedule during their junior and senior years as they do in the first two years. It must be looked for outside of the curriculum. A clue is found in the daily lament "I have no time". Upperclassmen have no time because they become involved in innumerable student activities from

which they were previously exempt. The many club meetings, shows, mass meetings, games, dances and hops, socials and smokers are continually draining the limited quantity of time. There is no wonder that scholarship must suffer.

Do the benefits bestowed upon the participants in these countless extra-curricular affairs warrant the loss in scholastic benefits? It would be rash to answer this question with a sweeping "yes" or "no", for student activities are too varied in nature to be generalized upon by a single word. Unfortunately, just this thing has been done by many superficial observers of college life. Critics who live outside the university quadrangle sometimes see nothing but the revelry and rowdyism of a small minority which is magnified and charged against the entire student body, while inside of the university walls men too often throw the balance over in favor of an extensive interest in the "activities" at the expense of the struggling demands of scholarship. Equilibrium must be secured by a careful discrimination between the desirable and undesirable, the legitimate and the spurious interests. Those that do not harmonize with the proper function of the university and do not make an advance toward its ideals, no matter how indirectly, should be discarded and condemned. Some must forfeit their prominence, no doubt, when subject to this censure, for there are many that have small value in furthering the real purposes of the university.

The purpose of the university we may agree upon as the developments in properly qualified students of those latent powers which will make of them earnest and competent leaders in thought and social welfare.

At the risk of being commonplace in criticism we urge a consideration of the true value of athletics as a means toward the accomplishment of this end. When men become so intimately bound in watching the fluctuations of the fortunes of a team or of individual players that this forms the major subject of their conversation and thought; that they will sacrifice a night's sleep to procure a good seat at a game; and that they will even go so far as to demand an "Extra" in their daily paper to hear of each incident of the game immediately after it is over, then the guarding critic must, indeed be charged with neglect of duty if he does not cry "halt!" "The real value of an athletic contest," says Ed. E. Slosson, now Editor of the Independent, "may be represented by a fraction whose numerator is the number of players and whose denominator is the

number of watchers present or absent. For every man who takes part in an athletic contest personally there are a hundred who take part by proxy and a thousand in absentia." When athletics clinch the attention of students to this extent, how is it possible to heed the calling of text books, justly clamoring for recognition? Unless the outcome of the game be subordinated to the outcome of the recitations or examinations there can be no justification for the athletic contest as a recreation from the more serious occupations of study.

If athletics predominate over all other interests why are they tolerated by the faculty; moreover why do even the highest executives attend the contests which they know do not, as they are now carried on, serve the university in the best capacity? Here again the majority rules, student opinion forces professors into giving an overt sanction. We, as students, must take the initiative, if we wish to maintain our supremacy we must also assume the responsibility of reflecting upon the problems that concern us. Grand-stand athletics present a problem and *we* must solve it.

But athletics, altho the major interest, is only one of many that have more or less of a deleterious effect in diverting application from study. "The side shows are so numerous," noted Woodrow Wilson while President of Princeton, "so diverting—so important if you will— that they have swallowed up the circus and those who perform in the main tent must often whistle for their audiences, discouraged and humiliated." Reform must come and we must be both reformers and reformed. Grand-stand athletics with several other student activities, must forfeit their present preëminence.

Let us move back into the room of which Tennyson speaks in his In Memoriam:

> Where once we held debate, a band
> Of youthful friends, in mind and art,
> And labor, and the changing mart,
> And all the framework of the mind.

Is there anything more thrilling than a heated discussion in a question of ethics or æsthetics? Can not literary clubs and social study clubs, too, evoke enthusiasm, or must we confess a lack of appreciation for the non-spectacular? These may be studious occupations but they are vital and do not blight the "free spontaneous life of impulse." They rather nurture it. In these activities there is little danger of a loss of interest in the important demands of the curriculum.

COLLEGE NOTES

No single large building will be constructed for the Engineering College during the coming year, but there will be a number of additions and constructions of considerable importance. The Board of Trustees has appropriated $25,000 to the Engineering College for a railway electrical laboratory which will be comparable in a way to the steam locomotive laboratory opened last spring. An addition to the transportation building will be erected costing about $33,000. It is expected that the library of the Engineering College will be located in the new portion. A wing of the Mining Engineering building, which was opened last year, will be constructed at a cost of about $16,000. In this the preparation of specimens for testing re-enforced concrete will be made. The Mechanical Engineering Laboratory will be reconstructed at an approximate cost of $26,000. When this completed it should be one of the notable laboratories of its kind in the country; it will accommodate some elaborate pieces of equipment.

On Saturday October 25th the following men were initiated into membership in Tau Beta Pi: J. W. Park, '14 A. E., A. W. Baumgarten, '14 E. E., H. V. Orr, '14 E. E., Winn D. Shipman, '14 C. E., H. W. Jory, '14, Arch., E. T. Reid, '14, E. E., C. R. Velzy, '14, M. E., Elmer McCormick, '14, M. E., and C. W. Lincoln, M. E., as Junior Honor Man.

Members of the 1914 Mechanical Engineering Class on returning to school this fall learned of the death of two of its most promising members.

On the last day of work for Cleveland, Cliffs Iron Co., just a few days before his expected return to school, Charles Sackrider met a tragic death by coming in contact with a live wire at the transformer house at the Maas mine in Nagaunee, Mich.

The other loss is that of W. H. Michael who passed away in the middle of summer as the result of pulmonary trouble developed at the University last winter. Mr. Michael was ambitious and will be remembered as one of the most conscientious workers of the mechanical engineering class.

DEPARTMENT NOTES

Electrical Engineering.

E. E. SOCIETY

The Electrical Engineering Society held their annual "feed" in the E. E. Lab. the first Friday in October. The purpose of the feed was to bring out the new men so that they could get acquainted both with the older men and with each other, and incidentally to secure as many memberships with as little work as possible. In both of these functions the 1914 feed was highly successful. Eats, to make people talkative and sociable were served in great abundance and had their desired effect. Freshmen, Sophomores, Juniors, Seniors, and Professors were all jostled together as the two hundred men took their turns in various "grub" lines. About nine o'clock a program was given consisting of short talks by some of the faculty and more prominent students. A motion to adjourn was passed at about ten o'clock, at which time about 120 men or practically 35% of all the E. E. students had taken out memberships for the ensuing year.

At 6:45 on the evening of October, 16, the first regular meeting of the E. E. Society was called to order by President Scott. After the minutes of the last meeting had been read and approved, the bills of last year's smoker and this year's feed were audited. The treasurers report showed that the finances of the society were in a very flourishing condition, the balance on hand being somewhat over $150. The old question of pins was brought up, and after a heated discussion, it was finally decided that the society should provide a pin for each one of its members. Nominations were then made for the senior representative of the E. E. Society on the Technograph board. E. B. Hatowski was elected. The speakers of the evening, Prof. Morgan Brooks, then gave a short address on "The Future of the Electrical Engineer." In introducing his subject he showed how Engineering twenty-five years ago was considered very little above manual laboring while at the present time it is classed as one of the professions. In the address proper, he reviewed all the fields open to the electrical engineer such as railway engineering, telegraphy, illumination etc., and gave a brief but very interesting discussion of each. The meeting was adjourned at eight o'clock.

E. A. James, '15.

Mr. P. S. Biegler has been appointed as Associate in Electrical Engineering. Mr. Biegler graduated from the University of Wisconsin with the degree of Bachelor of Science in Electrical Engineering in 1905. For two years he was with the Commonwealth Edison Co., of Chicago. He was Instructor and later Assistant Professor in Electrical Engineering at the University of Iowa, 1906-09. From 1909 to 1910 he was Assistant to the Electrical Engineer of the Washington Water Power Co. From here he went to Purdue as Assistant Professor of Electrical Engineering. Since 1911 he has been Assistant Professor and later Professor of Electrical Engineering at the University of Montana.

Mr. A. R. Knight has been appointed as Instructor in Electrical Engineering. He graduated from Ohio State University with the degree of Mechanical Engineer in Electrical Engineering in 1909. He has been in practical work with the Columbus Public Service Co. and the Dayton Lighting Co. From 1909-11 he was Inspector of Construction and Chief Electrician of the Springfield Light, Heat and Power Co. of Springfield Ohio. Since 1911 he has been instructor in Electrical Engineering at the University of Pennsylvania.

MECHANICAL ENGINEERING

During the past summer the machine shop has been changed considerably. The introduction of several new machines has greatly increased the usefulness of the shop and ought to be of a great value to Mr. Scroggin in demonstrating to the students the variety of work which can be done on one machine.

Perhaps the most interesting one of the new machines in the Horizontal Drilling, Boring and Milling Machine, manufactured by the Lucas Machine Tool Co. of Cleveland Ohio. The spindle on this machine can be adjusted for height, thus doing away with the old method of adjusting the table to the spindle. The most interesting feature is that a man can stand at one point and apply the feed to the spindle, in and out; to the spindle head and tail stock, up and down; to the saddle along the bed and to the platen across the saddle, without danger of engaging more than one feed at a time. This is accomplished by the use of improved interlocking devices.

Another of the new machines is a tilted turret lathe, manufactured by the Wood Turret Lathe Co. of Brazil, Ind. It is capable

of taking work up to an inch and a half in diameter. As the name implies this machine has a tilted turret which does away with the tendency to spring encountered in the old style turret.

A new "No. 2 Universal Cutter and Tool Grinder" manufactured by the Oesterlein Machine Co. of Cincinnati, Ohio has also been purchased. It is capable of grinding, milling, and gear cutters, reamers, gages, shafts, bushings, both external and internal, and all similar work.

A new line-shaft in two units has been put in. One unit has roller bearings and is driven through a Morris silent chain drive by a separate motor, while the other unit is belt driven and has the old style babbit bearings. By the use of the new line-shaft the vacant floor space has been brought together leaving room for expansion. The crane span has been changed from a twelve foot to an eight foot span in order to make room for the new line-shaft.

H. E. AUSTIN, '15.

Mr. L. A. Harding has been appointed as Professor of Experimental Mechanical Engineering. Mr. Harding graduated from Pennsylvania State College with the degree of Bachelor of Science in Mechanical Engineering in 1899. In 1907 he received his degree of Mechanical Engineer, at Cornell. Since then he has been in practical work with the Lackawana Steel Co. and the Armstrong Ark Co. of Pittsburgh, as manager of construction. From 1909-12 he was head of the department of mechanical engineering at Pennsylvania State College, and during the past year he has been in practice in New York City as consulting engineer.

Mr. H. W. Waterfall was appointed instructor in machine design. Mr. Waterfall is a graduate of "Boston Tech" where he was assistant in Mechanical Engineering 1911-12. For the past year he has been assistant to the chief engineer of the William Cramp & Sons, Ship and Engine Building Co., of Philadelphia.

Mr. F. C. Torrance has been appointed instructor in Mechanical engineering. Mr. Torrance is a Cornell graduate. Since graduation in 1911 he has been in practical work with the Tennessee Copper Co. and the Lackawana Steel Co. of Buffalo.

CIVIL ENGINEERING.

Despite inclement weather and numerous counter attractions, about one hundred and fifty students and faculty men were present at the annual smoker held at College Hall on October 10. Due to teamwork on the part of a very efficient smoker committee plenty of "eats" and "smokes" of good quality were provided. This paved the way for a good programme of talks.

President Lurie's opening address consisted chiefly of a talk on the need of the C. E. Club to back the Technograph both in a financial way and by furnishing articles, and on the plans of the executive committee to future programmes consisting of student experience talks and papers. Professor McDaniell's vigorous talk concerning the ability to make careful reports and use English clearly and concisely, followed.

Professor Wilson and Mr. Babbitt, two new members of the engineering faculty spoke on "Teaching versus a profession as a Monument Builder," and "The Glad Hand at Illinois."

Professor Baker's address was of more serious tone than usual, the run of stories being missing. The necessity of possessing the power of using clear, forcible English, and of having initiative—"the ability of going ahead on your own steam," were the themes of his address. The address of the evening was made by Mr. A. F. Robinson, Class 1880, bridge engineer of the Santa Fe System.

Mr. Robinson also told many interesting details concerning the reconstruction under his direction of "a little bridge (4000 feet long) over the Missouri River down at Sibley." Among other things, the successful use of concrete piles, and the difficulties encountered in raising the old bridge seven feet, under heavy and almost uninterrupted traffic were picturesquely described.

The meeting closed with the draining of the cider kegs at a late hour.

J. A. DEMUTH, '15.

MINING ENGINEERING.

The Student Branch of the American Institute of Mining Engineers held their annual "Get Acquainted" meeting October 2nd. at the residence of Professor H. H. Stoek. The meeting was a social gathering in order that the faculty and the students of the Department of Mining Engineering could become better acquainted. Short talks were given by the students on their summer experiences. Some of them did field work for the State

Geological Survey; others were in the copper mines at Bisbee, Arizona; the Lead Belt of Missouri; and the coal and iron district of Alabama. Mr. R. Y. Williams of the United States Bureau of Mines gave an interesting account of an experimental coal mine explosion in Pittsburgh. Mr. S. O. Andros, who spent the summer studying coal mining methods in Europe and visiting a number of foreign mining schools, gave a short resumé of the schools abroad and here. The import of his talk was clearly that our institutions are superior. Short talks were also given by Acting Dean C. R. Richards of the College of Engineering, Professor Stoek, and the two new members of the mining faculty—Prof. E. A. Holbrook and Prof. L. E. Young.

Professor E. A. Holbrook is a graduate of the Massachusetts Institute of Technology. After graduation, he was for several years in charge of mills and mines in Montana and British Columbia. Since 1909, he has been Professor of Mining Engineering at the Nova Scotia Technical College. During this last period, he also carried on professional consulting work.

Professor L. E. Young graduated from the Pennsylvania State College. Since graduation, he has carried on graduate work at Iowa State College, Michigan School of Mines and the University of Chicago. From 1909 to 1903, he was Assistant Professor of Mining at Iowa State College. From 1904 to 1907, he was Assistant Professor of Mining at the Colorado School of Mines. From 1907 to 1913, he was Director of the Missouri School of Mines. He has come to Illinois to pursue advanced work for the degree of Doctor in Economics, and, in the meanwhile, will give part of his time to instruction in Mining.

During the summer, all the machinery in the Mining Laboratory was put in order and several new machines installed. Some of the most important of these are a briquetting press, similar to that furnished the Bureau of Mines, to be used in testing briquett binders and utility of briquetts as fuel; a Williams coal crusher and pulverizer; a Frazier and Chalmers grinding barrel; and a Sullivan diamond drill outfit.

In the Ventilation Laboratory, there has been placed a Hailwood gas cap observation machine for safety lamps; an Orsat gas apparatus for the determination of flue and furnace gases; an electric relighter for safety lamps; and much other apparatus to be used during the course in Mine Ventilation.

To the collection in the Mining Museum, has been added a

model ventilating fan showing methods for the reversing of the air and also a model Stewart pan jig.

The class in Mining 3 has already made an inspection trip to the coal strippings near Danville. Plans are being made for field trips to other points of mining interest. On October twentieth the class in Mining 9 made a trip to the Mission Fields, to study some new wood construction.

Letters have been received from those graduates of 1913 who are now in the copper mines of the Braden Copper Company at Rancagua, Chile, South America. They are in the mountains where the air is cool and the skies are clear. The engineers, most of whom are from the States, live together. Their work is pleasant and the boys from here are very well satisfied.

S. T. WALLAGE, '15.

DEPARTMENT OF RAILWAY ENGINEERING AND ADMINSTRATION.

No changes have been made in the courses of Railway Transportation and Railway Traffic and Accountancy. This department is still housed within two rooms of Commerce Hall and the need of a Laboratory where the drafting of tariffs and computing of rates and practices in the making of schedules by students is greatly felt by all. However in spite of the lack of accommodations to give the student the practical training so necessary, many of the men who completed these courses are now in responsible positions. Chief among these are: C. P. Yin '11, Z. T. Zhen '10, and C. C. Wang '11. These men are now directing the railway enterprises of the Chinese Republic. Professor Adams, of Michigan, late statistician of the Interstate Commerce Commission. was appointed as chief adviser to the Chinese Commission on Government Railway Accounts, by the advice and the recommendation of the Department of Railway Administration at Illinois.

The Department of Railway Engineering has been more fortunate in securing commodious accommodations. To the quarters already available for the railway engineering courses additional room is planned.

The Railway Club commenced the season on schedule time. On Friday evening, October 3, the annual feed was given in its clubroom, 115 Transportation Building. With the rush and roar of a fast freight, the students of Railway Engineering and Adminis-

tration drew up along side the heavily laden "feed tables" and filled their empty cars to the brim.

Although the main purpose of the feed was to bring together the men of the different branches of the Railway Department and to make them acquainted with each other, several interesting talks were given. After outlining the subject of the club, President Featherston introduced the first speaker of the evening, Prof. E. C. Schmidt, head of the Railway Engineering College. Then followed talks by Prof. A. M. Buck, A. F. Comstock of the Railway Engineering Department and Prof. E. R. Dewsnup, head of the Department of Railway Administration in which they mentioned some of the great problems which face the railroad man of the present day. By the time the meeting was adjourned everybody was elated with the prospects for a successful year.

The next meeting was held on Friday evening, October 17th. The speaker of the evening was Mr. A. F. Comstock of the Railway C. E. Department. "Railway Signalling and its Problems" was the topic. A general discussion followed and after a short business transaction the meeting was adjourned.

MAX RUKIN, '15.

Among the buildings to be erected by the College of Engineering during the present year is an electric railway laboratory. This will be a companion building to the new locomotive laboratory, erected last year, and will stand directly west of it. Its dimensions will be the same as the locomotive laboratory, i. e. 40 ft. x 115 ft inside. It will be of steel construction, faced with brick, and surmounted by a reinforced concrete roof.

The building will be devoted primarily to a study of electric railway problems. Various types of railway motors will be arranged for testing, and a gallery running the entire length of the building will be provided for electric tests of rails and of light apparatus. A track will be included for the storage of the electric test car, now owned by the department, and space will be reserved for a sub-station to transform power for electric railway testing.

The transportation Building also will be completed this year by building an extension of forty-five feet to the north. It is planned to have space available here for a library to serve the entire College of Engineering, thus providing facilities which have been needed for several years.

A storage reservoir of 90,000 gallons' capacity is under con-

struction just east of the locomotive laboratory, which will furnish water for locomotive testing. It will be built of reinforced concrete poured in one continuous operation, and will be open on top. Only about two feet of the reservoir will project above ground.

The Chemical Club.

The Chemical club held its annual feed Tuesday evening, October 14. About 80 students and faculty men attended to hear the talks and to meet one another for a social time. The usual ginger bread, doughnuts, apples, and cider furnished refreshments.

G. B. Ruby, '15.

The main source of the inefficiency of education and the principal justification for the criticisms which have been made upon its results seem to me to lie in the students themselves. They go to college or technical schools, where they find afforded them abundant opportunities; but many of them are lacking in will, and are not able to avail themselves of them.

George Fillmore Swain.

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Vol. XXVIII January, 1914 No. 2

THE MECHANICS OF THE GYROSCOPE

BY FRED B. SEELY

Instructor in Theoretical and Applied Mechanics

High speeds of the moving parts of machines may be required for economy of operation or for the value of the high speed itself. In any case, the forces which are brought into existence due to the inertia of the moving parts, commonly called inertia forces and kinetic reactions, require careful attention. Elaborate methods have been devised to neutralize or balance the inertia forces in special cases, as in reducing the vibrations of the marine engine and to a lesser degree in the case of the locomotive. The stresses and deformations developed by the inertia forces are often of much importance and are in general much more difficult to estimate than stresses produced by static forces.

One of the most interesting examples of inertia forces and kinetic reactions is found in the gyroscope. Inertia forces in general and the kinetic reactions produced by them may be very undesirable and under extreme conditions even dangerous but in some cases they may be made very useful in accomplishing desired results. This is especially true in gyroscopic motion.

Recent applications of the gyroscope to engineering problems, especially its use in the stabilizing of ships, has given fresh interest to what for years has been considered mainly as a toy for children or as a problem to test the ability of mathematicians.

Gyroscopic motion comes under the observation of nearly everyone every day. And yet there is a popular feeling that gyroscopic action in some way contradicts the familiar laws of mechanics. The mechanics of the gyroscope as arising in or applied to engineering is not difficult although serious mistakes have been made in engineering problems where gyroscopic reactions

played an important part.* Before discussing gyroscopic motion, therefore, a brief statement of some of the fundamental principles of mechanics may prove of value. Emphasis should be laid upon the fact that mechanics is a physical science and that mathematics is only a tool used to express and interpret the physical laws. Observation and experience should be relied upon to give the physical meaning of mathematical equations. Newton's three laws of motion state in a concise and formal way most of the facts which follow.

The velocity of a particle has two inherent properties, magnitude or speed and direction. These two properties may be represented by a vector and any change in the velocity may be represented by a corresponding change in the vector. By definition, the rate of change of the velocity of a particle is the acceleration of the particle. It is evident that the acceleration may be (1) the rate of change of the magnitude of the velocity only, as in straight line (rectilinear) motion (2) the rate of change of the direction only, as in circular motion at constant speed or (3) the rate of change of both magnitude and direction simultaneously as in general curvilinear motion. Let a denote the total acceleration in each case we have for

$$(1) \qquad a = a_t = \frac{dv}{dt}$$

for

$$(2) \qquad a = a_n = \frac{v^2}{r}$$

for

$$(3) \qquad a = \sqrt{a_t^2 + a_n^2} = \sqrt{\left(\frac{dv}{dt}\right)^2 + \left(\frac{v^2}{r}\right)^2}$$

in which t and n denote directions tangent and normal to the path respectively while v represents the magnitude of the velocity at any instant when the particle is at a distance r from the center of curvature.

An acceleration of a particle is never produced except as a force is expended or used up in developing it. Conversely, an unbalanced force always fully expends itself in producing acceleration. The unbalanced force, F, required to produce an acceleration, a, in a particle of mass, m, is $F = ma$ (when proper units

* See *Nature* March 12, 1908.
Journal of the Franklin Institute August 1898 p. 105.
The Gyroscope p. 23, by F. J. B. Cordeiro.

are chosen). The acceleration may arise in any of the ways mentioned above. The direction of the force, F, is always in the direction of the change of the velocity.

In most engineering problems a force system acts on a system of particles (body) to which the following equations apply;

$$\Sigma F_x = M\bar{a}_x, \quad \Sigma F_y = M\bar{a}_y, \quad \Sigma F_z = M\bar{a}_z$$

which state that the component of the unbalanced part of the force system in any direction equals the component of the resistance developed, due to the inertia of the body, in the same direction. This inertia resistance is measured by the product of the mass of the body into the acceleration of the mass-center; a quantity factor times an intensity factor. The unbalanced part of the force system must equal the inertia resistance since it fully expends itself in developing this resistance. In other words, a force or couple cannot exist alone, the only way a force or couple can be developed or brought into existence being by or through the resistance offered by another body.

If the unbalanced part of the force system (resultant) is a couple which acts on a rigid body the body will rotate, then we have the principle that the couple, C, acting is measured by the rate of change of the angular momentum, $I\omega$, (also called moment of momentum) or

$$C = \frac{d(I\omega)}{dt} = I\frac{d\omega}{dt} = I\alpha$$

since the moment of inertia, I, of a rigid body remains constant and the rate of change of the angular velocity, $\frac{d\omega}{dt}$, is the angular acceleration α. $I\alpha$ represents the resisting inertia couple which the external couple, C, develops in expending itself. If the mass-system is not rigid, that is if I varies, then the external couple which must be introduced to maintain a constant angular velocity ω is

$$C = \frac{d(I\omega)}{dt} = \omega\frac{dI}{dt}$$

In both cases, it is assumed that the plane of rotation remains the same while C acts.

The gyroscope here considered will be a rigid body symmetrical with respect to three intersecting axes mutually at right angles, the body rotating or spinning about one of the axes with freedom to turn about one or both of the other two axes as the case may be.

Referring to Fig. 1a, let OZ, OX and OY be three intersecting axes mutually at right angles, $ABCD$ being a horizontal circular disc. Let the disc rotate or spin with a high constant angular velocity, ω, about the Z axis and at the same time let the disc turn about the Y axis with an angular velocity Ω. A particle, m, at the distance ρ (assumed at the circumference for convenience) from the center, O, will have a constant velocity, $\omega\rho$ in the plane of the disc. It will also have a velocity perpendicular to the plane of the disc (parallel to Z axis) due to the angular velocity Ω. This component of the total velocity, in one revolution of the disc about the Z axis, will change in magnitude from zero at A increasing downward to a maximum at B, then decreasing to zero at C, then increasing (in opposite direction) to a maximum at D and finally decreasing to zero at A again. The magnitude of this velocity is $\Omega\rho \cos \theta$.

As stated above a force is always required to change the magnitude of a velocity, the direction of the force being in the direction of the change in velocity. Hence a force must be acting downward on the particles which are traveling from D to B and upward on particles traveling from B to D. The velocity, $\omega\rho$ may be replaced by two components, one perpendicular to OY, $\omega\rho \sin \theta$, and one parallel to OY, $\omega\rho \cos \theta$. The component, $\omega\rho \cos \theta$, may be neglected as far as rotation about OY is concerned since the force causing a change in this component has no moment with respect to OY. The component $\omega\rho \sin \theta$ suffers a change in direction due to the angular velocity Ω. A force is required to change the direction of the velocity of a particle, the direction of this force being the same as the direction of the change in direction of the velocity. It is evident from the figure that this force acts downward on particles which are traveling from D to B and upward on particles traveling from B to D. The disc, therefore, due to these two forces acting on each particle, would start to rotate about the X axis unless a couple acted to prevent the turning. This couple is called the Gyroscopic Couple.

One of the simplest physical illustrations of this gyroscopic reaction is obtained by holding a bicycle wheel with one hand on either end of the projecting axle (dismounted from frame). If the wheel is spinning at a high velocity in a vertical plane, an attempt to turn the axle (and hands) in the horizontal plane will meet with resistance and the wheel will start to turn in the vertical plane unless the hands exert a couple to prevent this turning.

In order to determine the magnitude of the gyroscopic couple proceed as follows: The component of the acceleration of any particle, m, parallel to OZ is $a = a_1 + a_2$ where a_1 represents the rate of change of the magnitude of the velocity $\Omega\rho \cos \theta$ and a_2 represents the rate of change of direction of the velocity $\omega\rho \sin \theta$.

$$a_1 = \frac{d(\Omega\rho \cos \theta)}{dt} = \Omega\rho \sin \theta \frac{d\theta}{dt} = \Omega\rho \sin \theta\omega = \omega\Omega y$$

EF, Fig. 1b, represents the change in direction of the velocity $\omega\rho \sin \theta$ during an interval of time dt while the disc turns through an angle $d\varphi$ about OY. Hence, remembering that an arc equals

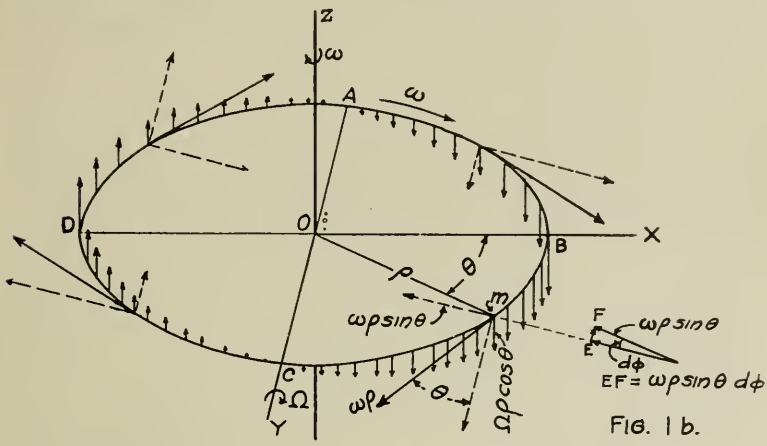


FIG. 1 a. FIG. 1 b.

the subtended angle times the radius and that the sine of a small angle equals the angle itself, we have;

$$a_2 = \frac{EF}{dt} = \frac{\omega\rho \sin \theta \, d\varphi}{dt} = \omega\rho \sin \theta \, \Omega = \omega\Omega y$$

therefore $$a = 2\omega\Omega y \,*$$

The force then acting on the particle of mass, m, perpendicular to the plane of the disc producing the acceleration a, is

$$F = m \times a = m \times 2\omega\Omega\rho \sin \theta = m \times 2\omega\Omega y$$

The moment of this force with respect to the X axis is

$$dL = F \times y = 2m\omega\Omega y^2$$

and the total gyroscopic couple is

$$L = \int dL = \int 2m\omega\Omega y^2 = 2I_x\omega\Omega$$

* It should be noted that this result could have been obtained with much less work by applying Coriolis's law.

but since the polar moment of inertia (with respect to Z axis) is $I = 2I_x$ we have

$$L = I\omega\Omega$$

The following conclusion may be drawn: If a rotating or spinning body is turned about an axis perpendicular to the axis of spin a couple will be set up about an axis perpendicular to the other two axes. The magnitude of the couple equals the product of the angular momentum of spin times the angular velocity of turning. Or, in other words, a body spinning about a Z axis with angular velocity ω, requires a couple $C = I\omega\Omega$ to maintain an angular velocity Ω about the Y axis. Ω is called the velocity of precession, or the body is said to precess with an angular velocity Ω.

Attention should be called however to the fact that $C = I\omega\Omega$ is the couple necessary to maintain a precession which has already been started. The inertia resistance which the body offers when the angular velocity is being established causes a lag and lead (surging) which may be studied from the equation

$$I\omega\Omega = I_x \frac{d\Omega}{dt} = I_x\dot{\Omega}$$

The surging action soon dies out however on account of friction and $\dot{\Omega}$ becomes zero as Ω becomes constant.

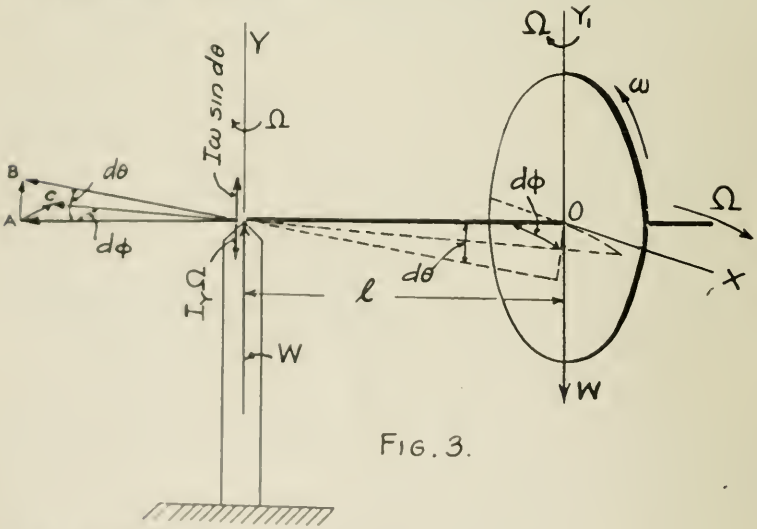


FIG. 3.

As shown in Fig. 3 the couple whose magnitude is Wl causes the disc and its axle to precess (in horizontal plane nearly) with

an angular velocity Ω. While the velocity Ω was being set up, however, that is while the inertia resistance of the disc and axle (as if not spinning), $I_x\psi$, was being overcome, the axle dropped or dipped slightly. After a certain ψ is developed an angular velocity greater than Ω is reached causing the disc and axle to rise again. This surging of the velocity of precession with the corresponding rise and fall of the axle has some rather interesting analogies in engineering problems.

From the equaton $a = 2\omega\Omega y$ it is noted that all points at the same distance, y, from the X axis have the same acceleration perpendicular to the disc. The resultant force acting ($\perp$ to disc) on each half as divided by the X axis may be found by summing up the forces $F = 2m\omega\Omega y$ for each half, which leads to the equation,

$$R_z = \frac{M}{2}\bar{a}_z = \frac{M}{2} \times 2\omega\Omega\bar{y} = M\omega\Omega\,\frac{4r}{3\pi}$$

The action line of each of these two resultants, R_z, passes through a point at a distance y_0 from the center along the Y axis as found from the moment equation

$$I\omega\Omega = M\omega\Omega\,\frac{4r}{3\pi} \times 2y_0 \text{ but since } I = \tfrac{1}{2}Mr^2 \text{ (for disc)}$$

$$y_0 = \frac{3\pi r}{16} = 0.59r$$

A disc or wheel rolling on a circular track is an illustration of gyroscopic motion. Many other examples of such motion will occur to the reader, such as locomotive drivers or automobile wheels and flywheels when rounding a curve, etc. A couple $C = I\omega\Omega$ is required to keep the disc from overturning, or in other words the gyroscopic couple of the drivers helps the centrifugal couple to overturn the locomotive. It is interesting to note that the line of zero acceleration perpendicular to the disc is at $y = -\frac{r}{2}$ as shown as follows: Referring to Fig. 2, the velocity of any point (assumed at the circumference for convenience) is made up of three components as shown. The component of the acceleration of this point which is parallel to the Z axis is $a = a_1 + a_2 + a_3$. a_1 and a_2 have the same meaning as in the case already considered $a_1 = a_2 = \omega\Omega y$. $a_3 = \Omega^2 R$ due to the rate of change of the direction of ΩR. Hence,

$$a = 2\,\omega\Omega y + \Omega^2 R$$

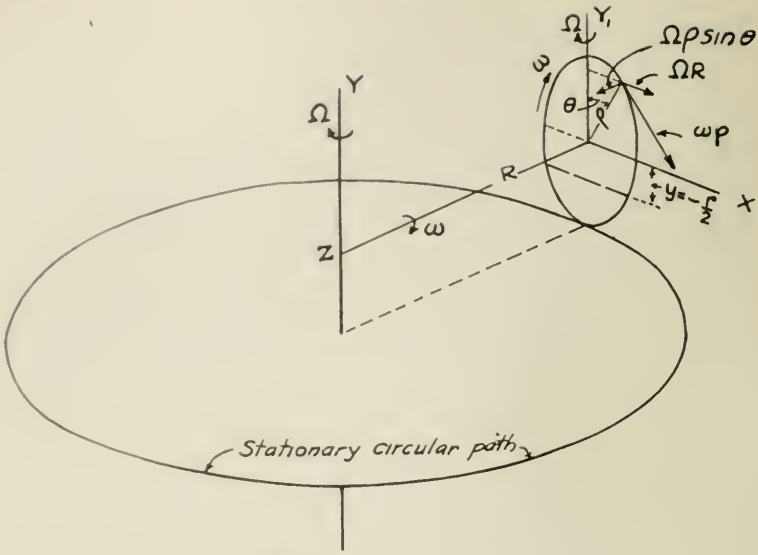


FIG. 2.

The velocity of the center of the disc is equal to the velocity of the rim or $\Omega R = \omega r$. Equating a to zero and solving for y we get,

$$y = -\frac{\Omega^2 R}{2\omega\Omega} = -\frac{r}{2}$$

that is, all points on a line parallel to the X diameter midway between the track and the X diameter have no acceleration parallel to the Z axis. All points above this line have accelerations directed toward the inside of the track and all points below this line have accelerations directed outward, the acceleration in each case being proportional to the distance from this line. The resultant of the forces producing these accelerations may easily be found. This leads to the fact that two equal masses fixed along any diameter at the same distance from the center of the disc would cause no uneven pressure on the track when running on a straight track and would cause variation in pressure when running on a curved track. It is an interesting fact easily proved that three or more masses arranged symmetrically with respect to OZ will cause no variation in pressure on either track. The variation in pressure in the case of a locomotive driver is very small even when running at high speed around a curve of the smallest radius.

As stated above, when an external couple acts on a rigid body the angular momentum of the body, $I\omega$, will change, the magnitude

of the couple being measured by the rate at which the angular momentum changes. The three properties of an angular momentum which are involved in its physical meaning are (1) magnitude, (2) sense of rotation, (3) direction (not location) of the plane of rotation, as specified by the angle which the plane of rotation (or its normal makes with some fixed plane (or line). A vector may fully represent these three factors by drawing it of a proper length to some scale perpendicular to the plane of rotation with the arrow pointing in the direction in which a right-handed screw would advance if turned in the direction of rotation. Any change in the angular momentum is fully represented by the corresponding change in the vector. The couple required to produce this change is always in a plane perpendicular to the vector representing the rate of change in the angular momentum.

It is evident that the rate of change of $I\omega$ may be (1) the rate of change of the magnitude only, as given by $I\frac{d\omega}{dt} = I\alpha$ or (2) the rate of change of the direction of the $I\omega$ vector only or (3) the rate of change of both magnitude and direction.

The principle of conservation of angular momentum states that if no external couple acts in a given plane on a system of particles the angular momentum of the system with respect to an axis perpendicular to the plane remains unchanged.

A few familiar illustrations may serve to make clear the physical meaning of the principles mentioned above. Let two pulleys be mounted on a rotating shaft, one keyed to the shaft, and rotating with it, the other loose (not rotating). Let a clutch operate to suddenly throw in the loose pulley thus starting it to rotate with the tight pulley and axle. The angular momentum of the whole system before the clutch was operated was $I_1\omega_1$. By throwing in the clutch the moment of inertia of the rotating system was increased to $(I_1 + I_2)$ while the angular velocity decreased to ω_2. But from the principle of conservation of angular momentum we get,

$$I_1\,\omega_1 = (I_1 + I_2)\,\omega_2 \quad \text{or} \quad \omega_2 = \frac{I_1}{I_1 + I_2} \cdot \times\, \omega_1$$

The angular velocity ω_2 is reached after a surging action dies out. While these vibrations are being extinguished kinetic energy is lost. The kinetic energy of the whole system before the clutch

was operated was $\frac{1}{2} I_1\omega_1^2$ and after the two pulleys have come to a constant velocity, ω_2, the kinetic energy of the system is

$$\tfrac{1}{2}(I_1 + I_2)\omega_2^2 = \tfrac{1}{2}(I_1 + I_2)\frac{I_1^2}{(I_1 + I_2)^2}\omega_1^2 = \tfrac{1}{2} I_1\omega_1^2 \left\{\frac{I_1}{I_1 + I_2}\right\}$$

hence

$$\left\{(1 - \frac{I_1}{I_1 + I_2}\right\}.$$

represents the part of the original kinetic energy which is dissipated. This is analogous to the loss of energy in setting up precession in the gyroscope.

A man if standing on a platform which is revolving with an angular velocity ω can decrease the ω by extending his arms thus increasing his moment of inertia. This develops a friction couple on the soles of his shoes but the product $I\omega$ for the man and platform must remain constant or, if ω is to be kept constant an external couple, C, must be applied to the platform such that

$$C = \omega \frac{dI}{dt}.$$

A gymnast leaving the swinging trapeze at the top of a circus tent with angular velocity ω, his body being extended, may make several complete turns in mid-air as he descends in the vertical plane by "doubling up". This decreases his moment of inertia and gives him a corresponding increase in angular velocity the product $I\omega$ remaining constant since no couple acts in the vertical plane.

As is well known, a cat when held by the four feet will, if dropped, always turn through one half a revolution and light on its four feet, (providing it is held a reasonable distance from the floor). This is easily explained by the principle of conservation of angular momentum. The $I\omega$ of the cat with respect to an axis corresponding to its long dimension is zero when its feet are released and must remain zero during its fall since no couple acts to change this angular momentum. For small relative displacements the cat may be considered as made up of a fore and hind part with a swivel at the center. Let I_1 and I_2 represent the moment of inertia of the fore and hind parts respectively. By extending the hind legs and contracting the fore legs the fore part is turned in one direction throwing the hind part in the opposite direction. Since however $I_2 > I_1$ there is a net gain in favor of the fore part. Now by extending the fore legs and contracting the hind

legs the hind part is turned, throwing the fore part back but to a less extent since now $I_1 > I_2$. By a rapid succession of such actions and reactions the cat makes one-half a turn. The reader may, by the same method, turn through any desired angle, when sitting on a swiveled chair, by extending his legs and contracting his arms etc., etc. The action is more positive if weights are held in the hands.

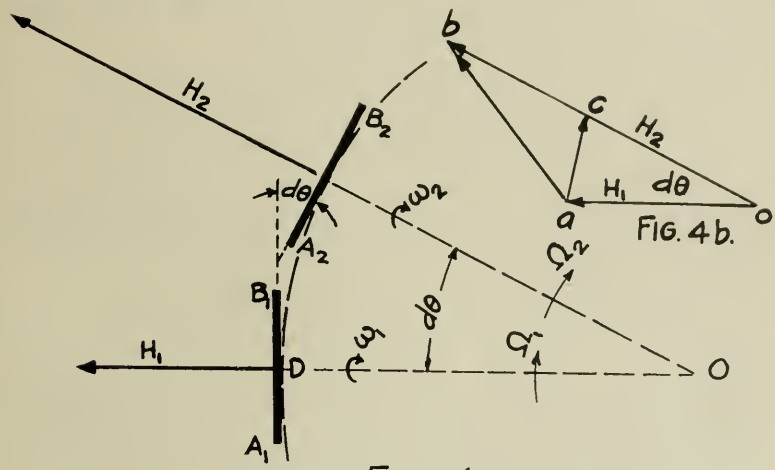


FIG. 4a

In the above illustrations the change in the angular momentum was either zero or a change in magnitude only. That is, the plane of rotation remained the same, or in other words, the vector representing $I\omega$ changed in length only. In gyroscopic motion the $I\omega$ vector changes direction.

As has been stated, a disc rolling around a curved path is revolving simultaneously about two axes mutually at right angles. This example of gyroscopic motion together with the case as shown in Fig. 3 will be used (for convenience) to show the applications of the foregoing principles concerning angular momentum.

Referring to Fig. 4a, let A_1B_1 represent the disc at a given instant when its angular velocity about its axle, OD, is ω_1 and its angular velocity around the curve (also its angular velocity about an axis through D perpendicular to plane of paper) is Ω_1. Let A_2B_2 represent the disc after an interval of time dt the angular velocities having increased to ω_2 and Ω_2. The plane of the disc during the time dt turns through an angle $d\theta$. Let H stand for angular momentum. The angular momentum of the disc at the

first instant is represented by $H_1 = (I\omega)_1$ and after the internal dt it is $H_2 = (I\omega)_2$. The change in H is ab (exaggerated) Fig. 4b. This change is due to a change in direction of H, represented by ac, plus vectorially the change in magnitude represented by cb. A couple is always necessary to produce a change in H the magnitude of the couple being the rate of change of H, the plane in which it acts being perpendicular to the vector representing the rate of change of H and its sense of rotation being determined from the direction of the arrow.

The rate of change in the magnitude of H is

$$\frac{cb}{dt} = \frac{dH_1}{dt} = \frac{d(I\omega)_1}{dt} = I\frac{d\omega_1}{dt} = I\alpha_1$$

I being constant.

The direction of cb is perpendicular to the plane of the disc. Hence a couple $C_1 = I\alpha_1$ acts in the plane of the disc causing the disc to roll faster.

The rate of change of the direction of H is

$$\frac{ac}{dt} = \frac{H_1\, d\theta}{dt} = I\omega_1\Omega$$

cb and ac are perpendicular to each other, for the infinitesimal angle $d\theta$. Hence a couple $C_2 = I\omega_1\Omega_1$ acts in the plane of the paper (perpendicular to plane of disc) in a clockwise direction. In other words the disc would tend to overturn unless a couple C_2 acted to prevent the overturning.

As already shown $C_2 = I\omega\Omega$ is the gyroscopic couple. If ω is constant C_1 = zero, the total change in H then being ac and the only couple required to maintain the velocity Ω being the gyroscopic couple.

When the body is allowed to precess the external couple acting on the body will be resisted by the gyroscopic couple. This is readily seen by following the changes in the angular momentum. in Fig. 3. When the couple, Wl, first acts the change in the angular momentum produced is AB vertically upward. This requires a couple in the horizontal plane in an anti-clockwise direction but since there are no bodies to develop or supply this couple the disc turns (precesses) clockwise in the horizontal plane developing the necessary couple ($I_y\dot{\psi}$) from the inertia of the disc. As soon as precession starts however the change AC is produced in the angular momentum. This requires a clockwise couple in the vertical plane to prevent the disc and axle from rotating anti-clockwise in the vertical plane. This couple is supplied by the

two forces W having a moment Wl. Hence if the body is allowed to precess the external couple Wl is resisted by the gyroscopic couple or

$$Wl = I\omega\Omega = \frac{W}{g} k^2\omega\Omega$$

from which the velocity of precession $\Omega = \frac{lg}{\omega k^2}$, k being the radius of gyration of the disc and axle with respect to the y axis.

If precession is prevented a couple $C = I\omega\Omega$ must be set up in the horizontal plane, Ω here being the angular velocity at any instant produced by Wl which will be the same whether the disc rotates or not, there being no resistance offered to the external couple unless precession is allowed. This explains why a heavy rotating flywheel or armature on board a ship, with axle horizontal and athwartship, will offer no more resistance to the rolling of the ship than if not rotating. The bearings of the axles however must exert a large couple $C = I\omega\Omega$ in a horizontal plane which tends to "nose around" the ship. Ω here represents the angular velocity of roll. It is evident that rotating bodies aboard ship will be subjected to less stress when their axes are parallel to the fore and aft direction in which case Ω would be due to the pitching of the ship.

If an external couple is applied in a horizontal plane, fig. 3, to increase or hurry the precession the disc and axle will rise, since $I\omega\Omega > Wl$. This is the principle employed in Brennen's monorail car, the precession being hurried by the rolling of the axle of the revolving fly-wheels, extended, on a shelf attached to the side of the car. This principle is also used in the "active type" of gyroscope for stabilizing ships. In this case the precession is hurried by means of a precession engine which acts after the ship has rolled a very small degree thus producing a gyroscopic righting couple just sufficient to extinguish the roll. Since the roll is checked in its incipiency only a small amount of work is done. The stresses produced in the hull of the ship are also small for the same reason. The weight and displacement of the gyroscope may likewise be small.

As already pointed out, energy is dissipated in establishing precession. In order to start the disc and axle, Fig. 3, precessing the axle must dip due to the couple Wl through an angle $d\theta$. The work done during this displacement is $Wld\theta$. This work generates

a certain amount of kinetic energy which appears as the kinetic energy of precession which is expressed by $\frac{1}{2} I_y \Omega^2$. The work $W'ld\theta$ however is not all expended in producing this kinetic energy as may be shown as follows: When the axle dips an angle $d\theta$ the component of the angular momentum, $I\omega$, parallel to the y axis is $I\omega \sin d\theta$. The total angular momentum with respect to the Y axis must be zero (conservation of angular momentum) hence the angular momentum of precession $I_y\Omega$ must neutralize this component or

$$I\omega \sin d\theta = I_y\Omega; \text{ multiplying by } \tfrac{1}{2}\,\Omega \text{ we get,}$$

$$\tfrac{1}{2} I\omega\Omega \sin d\theta = I_y\Omega^2$$

$$\text{But } W'l = I\omega\Omega$$

$$\therefore \tfrac{1}{2}\, W'ld\theta = \tfrac{1}{2}\, I_y\Omega^2$$

that is, one half of the work expended is transformed into kinetic energy of precession the other half is dissipated through the friction which reduces the surging.

"Lord Kelvin first pointed out that if currents of a system are kept constant by a battery during a displacement in which the electro-kinetic energy is increased by W, an equal quantity W of energy is dissipated from the wires as heat, the battery being thus drawn upon for a double quantity of energy $2W$"*.

For those interested in the various ways in which gyroscopic motion may arise and in the progress which has been made in the application of the gyroscope to the stabilizing of ships, monorail cars, and aeroplanes, to the guiding of torpedoes, to compasses, and to the Griffin grinding mill the following references are appended:

1. *Journal of The Franklin Institute*, May, 1913.
2. *American Machinist*, August 7 and 14, 1913.
3. *Iron Age*, December 1, 8, 15, and 22, 1910.
4. *Scientific American* Supplement, January 26, 1907.
5. *Popular Science Monthly*, July, 1909.

*Quoted from "Spinning Tops and Gyroscopic Motion" by H. Crabtree. See Maxwell's *Electricity and Magnetism*" 3rd edition, Vol. II, p. 225.

INDIRECT LIGHTING APPLIED

BY LEONARD V. JAMES, E. E.
Associate in Electrical Engineering

In a previous article the principles underlying good illumination were discussed at length. Among other things determined as a result of this study was that it is necessary in a satisfactory system to protect the eyes from too great contrasts in intensity as well as to provide for distribution and diffusion of the light rays. It was suggested that one system which makes much of eye-protection and of diffusion of light is the so-called eye-comfort or indirect system. A more complete discussion of this system as practically applied is given here. The installaton of plain fixtures alone will be considered, possible artistic effects and fixtures being reserved for a future article.

Any system of illumination depending upon reflection to direct the rays of light to the objects illuminated might be termed an indirect system. Thus daylight is really indirect, especially indoors, the clouds and the objects on the earth redirecting the sun's rays so that they enter the room. Moonlight is another example of this lighting, although none of the advantages of indirect are found, the shadows and contrasts being less noticeable than in straight direct lighting only because of a less brilliant source.

There are a number of artificial systems of lighting utilizing this principle of reflection of the rays from extended areas of enlarged sources, these areas being either a part of the fixture or of the ceiling. Losses of light energy occur in these systems in two places, first in the reflector within the fixture and again where the rays are redirected from the ceiling or other large surface. One very successful system uses silver-mirrored reflectors for each lamp in the fixture making it convenient to have these reflectors of scientific design as well as providing the highest efficiency possible. Complete diffusion of the rays is obtained by means of corrugations while long life is assured by coating the outside with an elastic enamel. The arrangement thus is such that a very large per cent of all the light produced in the fixture is directed to that part of the ceiling where it will accomplish most in providing general illumination in the room. Sections of fixtures so equipped

are shown in Figures 1 and 2. The containing bowl is opaque in this case; the same may be made of translucent material and illuminated from within for artistic effect but to try to secure useful light through this bowl seems to mean a decreased efficiency for the unit.

There seems to be a tendency to associate light ceilings and walls with indirect lighting but to give no thought as to how many of the rays are directed to the ceiling and the manner of their direction, matters of equal if not greater importance than the color of the decoration. Reference to the several diagrams in the preceding article shows that most of the light on the working-plane comes from a limited part of the ceiling, but little being reflected from the walls, while experience teaches that the color of the walls does not have a marked effect upon the results. For

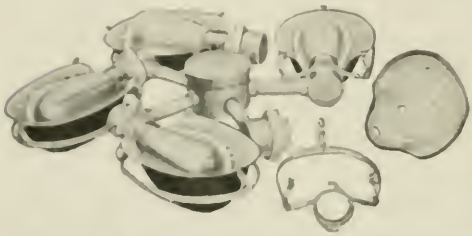


FIG. 1 Multi-unit fixture, showing reflectors.

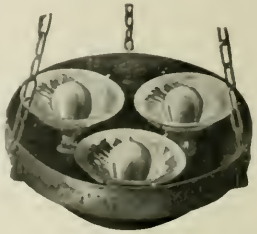


FIG. 2. Multi-unit equipment, shallow reflectors.

these reasons, the reflectors in the fixtures should be designed so that the light will be limited largely to that part of the ceiling where it will do the most good, only enough being directed beyond that area to light the rest of the ceiling and the upper walls so that they can be seen.

Since the ceiling plays so important a part in an installation of indirect lighting, its surface should have high diffusing and reflecting qualities,—that is, should be somewhat rough so as to reflect the light in all directions, most of the light directed to it being reflected. An almost ideal surface for these purposes is white blotting paper which has nearly as high a reflection coefficient as the ordinary mirror but so scatters or diffuses the rays that most people are surprised when they learn this fact. Thus that white or cream ceilings give the best effect, but should be rough rather than glossy. Pale blue or pink tints have been

known to give fair results, but even light shades of the heavier colors should be avoided. As previously suggested, except in very small rooms, the influence of the walls upon the illumination is slight, so that any colors harmonizing with the ceiling may be chosen, except that a drop or border of a light shade sometimes seems desirable for general effect. It has been noticed that light colored walls are more necessary for satisfactory daylight and direct lighting than where the indirect system is used.

The accompanying photographs of installations were made, practically without exception, with the indirect light alone. The excellent diffusion afforded appears in the absence of glary spots and dense shadows. The resulting "softness" is very easy on the eyes, or technically speaking the absence of sharp contrasts relieves the eyes from the muscular strain to which they are accustomed when used in most artificial light or even in some cases of natural light. The result is not only that the user of the light finds greater comfort but he is completely satisfied with a much lower intensity, a condition discussed in the previous article on principles of illumination and shown to be possible where the illumination is proper.

One of the most interesting among recent installations of indirect lighting is in the new Hub (Henry C. Lytton and Son), Chicago. The main floor in this large store is equipped with luminous bowl fixtures suggested on a previous page and described in a subsequent article on this class of fixture. Figure 3 shows a representative floor in the Hub. The bowls are of special design and of old ivory finish, and each one contains a 250-watt mazda lamp with suitable reflector. There are four of these fixtures per bay of about 500 square feet so that the power consumption is two watts per square foot. The resulting illumination is 5.4 foot-candles which is high for this class of service and is giving perfect satisfaction. The ceiling and walls are ivory white in finish. It has been found desirable to clean the reflectors every few weeks, a slightly dampened cloth being used. If indirect lighting can force people to give this kind of attention regularly to their electric fixtures it will have brought about a real economy all along the line for it is noteworthy that reflectors are seldom cleaned as frequently as they should be if their average efficiency is even to approach their best efficiency. As a suggestion, try a mirror with and without a slight film of dust.

FIG. 3. Typical Clothing Floor in the Hub, Chicago

FIG. 4. The Englewood Theatre, Chicago

The Englewood Theatre in Chicago, Figure 4, shows how well this class of interior is handled by indirect lighting. While the auditorium lamps in a theatre are used so little that the expense of operating the same is small, it is probable that a similarly satisfactory system of direct lighting would require as much if not more energy than the one here installed. The economical advantage here, however, is in the small number of fixtures required, while the advantage in the illumination secured is apparent. The effect is even more pleasing in a moving picture theatre where one lamp in each fixture may be turned on continuously throughout the performance, giving a soft dim light which will

FIG. 5. Masonic Hall, Auditorium Hotel, Chicago

enable people to move around but will not interfere in the least with the picture being shown.

The use of the indirect system in large auditoriums is shown in Figures 5 and 6. The Masonic Hall, Figure 5, is particularly interesting because of its former use as an Egyptian banquet room, when direct lighting was used. In each case decorative features have been embodied in the lighting plan; without these and using mazda lamps throughout the direct system would have cost over three times as much for operation as the present installation. Definite figures are not available giving the illumination in foot-candles in the banquet hall but it is not probable that the effective light was much more than in the present hall where there is an average of about two foot-candles—nearly office illumination.

The auditorium and ball-room at the South Shore Country Club, Chicago, (Figure 6) is lighted by three large and very elaborate fixtures in the main part of the hall, and by a number of small fixtures in the promenade. This was another place where a saving was effected by using the indirect system. It was wired and planned for direct lighting; by changing over there was an actual saving in fixtures and lamps of over $700, and the cost of operation was reduced twenty per cent.

The matter of relative economies is one which hardly should be considered without bearing in mind other advantages. Still it is

FIG. 6. Ball-room, South Shore Country Club, Chicago

sometimes desired to make comparisons on the basis of the cost of operation alone. Numerous instances like the ones just referred to indicate that the indirect system of lighting is at least on equal footing with the direct where adequate illumination is required throughout the entire area to be lighted. While this condition holds for most interiors special cases exist which present special problems. Thus it will obviously be more expensive to light an entire large living room when merely localized lighting at the reading table is desired. Here, with direct lighting, the table might be placed near the lamps and but one of them used. This is an unusual condition, however, even in homes, for general illumination is required in parlors, dining rooms, bedrooms, etc.

Such a dining room is shown in Figure 7, where more energy is used than in most dining rooms but where more than the table itself is lighted and where there are no bright filaments exposed to blind the people in the room.

A representative library installation is that in the civics reading room, Chicago Public Library, shown in Figure 8. The ceiling

FIG. 7. Indirect Lighting in a Dining Room

FIG. 8. Civics Reading Room, Chicago Public Library

to a light cream, the walls are light buff on the upper half and light Italian marble below, and the furniture is dark. Single-unit fixtures, each containing one 400-watt lamp, are used with excellent effect.

The absence of shadows and the good distribution obtained by using the indirect system are doing much to popularize that system for use in office buildings. Figure 9 shows the County

FIG. 9. County Clerk's Office, Multnomah County Court House, Portland, Oregon

Clerk's office in the Multnomah Co. Court House at Portland, Oregon, two wings of which building are lighted by indirect entirely. A high average illumination of nearly four foot-candles is obtained with an energy consumption of about one and a half watts per square foot. The ceiling in this case is also of light cream. Further office views are given in Figure 10, showing four representative rooms in the Armour General Office Bldg., Chicago. The upper *left* view shows the president's office

Fig. 10.—Armour General Office Building, with Interiors, Chicago

illuminated to nearly three foot-candles by one 500-watt fixture, the upper *right* shows a part of the general offices which are lighted by 100-watt lamps and the lower *left* is the ladies' rest room lighted in the same manner as the general offices but at a lower intensity. The barber shop shown in the lower *right* corner merits considerable attention, especially because of the peculiar conditions involved. Among the advantages obtained by installing indirect is that the absence of all shadows makes it unnecessary for the barber to choose his position with the light in mind, while the occupant of the chair finds it agreeable to look up to a moderately illuminated ceiling instead of into a glaring reflector. The Armour Bldg. is equipped throughout with indirect lighting, a special and inexpensive fixture having been designed by the company making the installation and called by them the "Armour fixture."

WILLIAM THOMPSON—LORD KELVIN

As one who, waking ere the morning light
Stirred by a force beyond the common ken,
Scorns each inducement to repose again.
Such is the vision, bursting on his sight;
And rising steadfast in resistless might
Forged by a faith that makes men more than men
Like him of strength as of the strength of ten,
Essays the weary guest across the night.
So here, amid the shadows of a time
Blinded to nature's portal splendid fire,
This man, beholding with a faith sublime,
Braving the dark, sought out the golden key.
Gaining while others slept the lustrous prime
Of truths released for all posterity.

Frank A. Farnsworth Jr., in *Edison Monthly*.

*SOME SUGGESTIONS TO THE UNDERGRADUATE

BY A. F. ROBINSON, '80

Bridge Engineer of the Santa Fe System

Some of our legal and political friends have attempted to fix the field of engineering within very narrow limits. The final breadth of the field will depend in large measure on the practising engineers themselves.

We must not forget that broad economic questions are of even more importance than the actual details of construction. In fact, the proper solution of these economic questions is the defense for the kind of construction used. The field of engineering must not be limited to the mere laying out of a line and constructing it.

I have often been asked why engineers do not hold a larger percentage of the high positions in national and commercial enterprises. I think it is generally admitted that lawyers are in the majority in the President's cabinet, in the U. S. Senate and the House; also in State affairs. Further, they hold very many prominent places with our railway corporations and other large commercial enterprises. I think there are good reasons for this. I also believe that the engineers should in the near future be very much more prominent, especially in railway and commercial affairs than they have been in the past.

The reasons for lawyers holding prominent places may be roughly grouped as follows:

1. They are good pleaders; they learn to state their cases in the strongest manner possible.

2. The better class of lawyers are masters of the art of brevity; they give the clearest and most convincing presentation of their cases in the fewest words possible. Recently a Chicago lawyer received a $10,000 fee for one word.

3. Lawyers control to a large extent the details of contracts, organization papers, and working program for all business enterprises. They also exercise similar control over the make up of laws and legislative enactments. They therefore naturally make ample provision for their profession.

We seldom find engineers who are masters of the art of proper presentation, as a class they are not good pleaders or good talkers.

*Address delivered before the Civil Engineer's Club at their smoker, Oct. 10, 1913.

Most of their training has apparently been toward finding out facts, the study of mathematics and other branches of engineering while the proper presentation of what they have learned has been in a great measure neglected.

During the past twenty-five years it has been my privilege to have a good many engineers in my office force. Scarcely one man in ten is able to make a report on an ordinary engineering investigation that I could accept as my own. Few of the men seem to appreciate the value of the clearest and most forcible presentation of the matter in hand in the fewest possible words. This fault does not apply to the graduates from any one institution; it applies to all of them with whom I have had any acquaintance.

These faults may possibly be due to some omissions in the regular university studies. The courses as now laid out keep our students busy all of the time. It would be a hard matter to crowd in enough work in the line of presenting cases to make it worth while without infringing, more or less, on other important studies. My idea in presenting this matter to freshmen and sophomore engineers is to see if they cannot help somewhat in the matter.

Generally the time of the student is devoted almost entirely to learning his lessons and very little time is given to the matter of making the recitations or presenting the various cases. I believe the instructors in our universities would tell you that not one student in ten pays much attention to the manner in which recitations are made; i. e., as to the clearness of his demonstration and the brevity of same. Will it not be possible for our freshmen when they commence, to devote a small portion of their time to the manner in which their recitations are made? i. e., to the matter of presenting their cases. I think if this idea is fixed in the minds of the students from the time they enter the University and followed consistently through their course, they will all of them be much better able to make a clear, forcible and concise presentation of any cases that may come before them. It seems to me this is a matter that concerns the student fully as much as the instructor, if not more.

I am making these suggestions as a beginning, thinking that if the next generation of students shows a decided improvement the faculty will find a way of following the matter up further.

We must not expect to solve the entire problem the first attempt.

Engineering as a profession has been accepted as a kind of a necessary evil after only a few generations of trial. The final position of engineering will rest with the present and the next two or three generations. Will they be able to solve the problems and carry the burdens now being placed on them by society? Many generations of lawyers were required before that profession was firmly established.

Babson in a recent lecture before the Chicago Engineers' Club said: "Lawyers are trained to evade or out-wit the law. Engineers, on the other hand, must be honest, since they are dealing with the laws of nature and with fundamental basic principles." It seems to me one of our greatest weaknesses as a profession is in the presentation of our cases as previously noted.

Twenty-five years or more ago, when the speaker commenced active work, the field of engineering was almost entirely occupied by the so-called self-educated man. The college bred engineer was looked upon as a sort of a curiosity or an "educated lunatic." Today there are few of these self-educated engineers in active service; they have been replaced by the college bred engineer. Railways and all of the great commercial enterprises require engineers having the very best of training. Today one of the questions asked about a man either in high position or a young man applying for a place is "What university is he from?" Most of our railways and large commercial enterprises will not employ men unless they have received a thorough college training.

The trend of opinion seems to indicate that there will be almost an unlimited field for the engineers that are able to give the kind of service that is required of them. The present generation of engineers has carried a heavy burden; they have been making a field and at the same time working it. The coming generations will have to carry a still heavier burden. The outlook for them is almost beyond measure. It therefore stands us in hand to make ample provision to meet all the demands of the general public.

I believe if our young engineers will take the full college course having in mind the fact that the learning of lessons is only one part of the process; if they will endeavor to present their recitations every day in the clearest and most forcible of language, at the same time keeping in mind brevity, we will have in due course a generation of engineers that will be holding positions as chief

engineers, vice-presidents and presidents of the various railway and commercial enterprises. We will then have men who are really engineers, men who are able to solve the problems put before them and then present their results in proper form for consideration. Soon after this time comes we will find engineers occupying positions of trust and shaping not only railway and commercial enterprises, but also having a voice in legislative affairs.

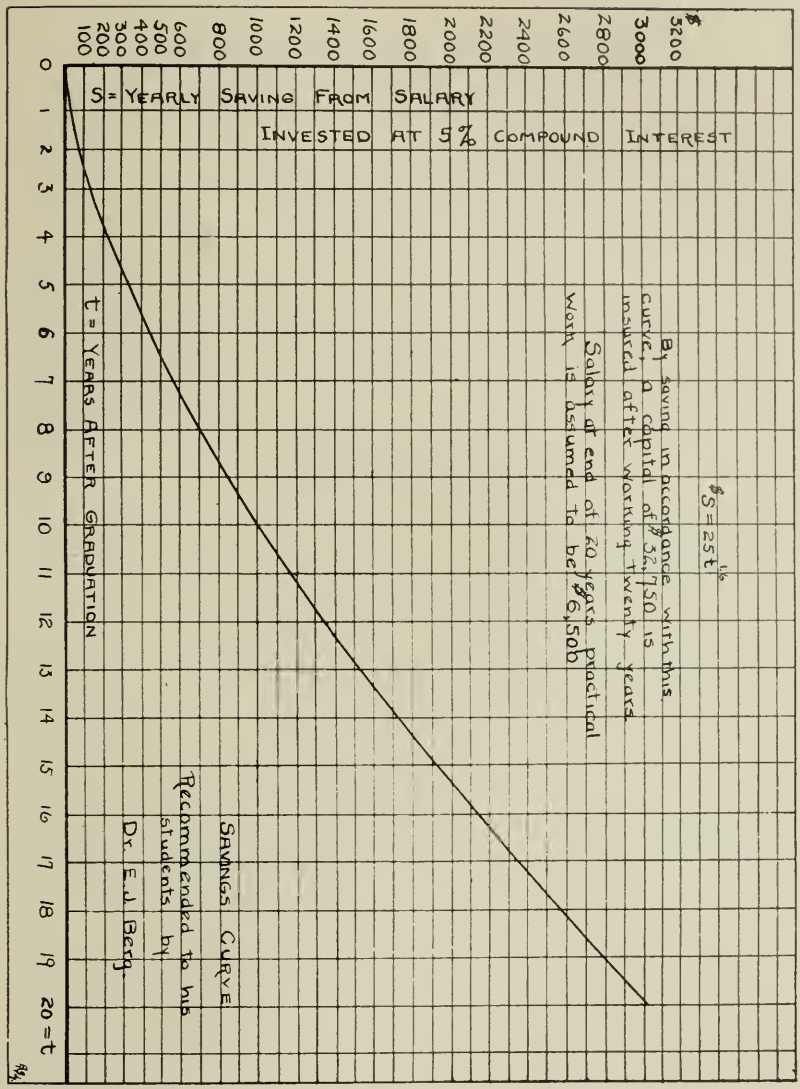
THE ARC LIGHT

All night, all night, I swing and sway,
Above the city's quiet way.
Gone the crowds that evening knew,
Gone the last belated few.
Sleep reigns the silent city through,
While round me windows, shutterless,
Reflect my light in loneliness.

The watchman ever and anon
Approaches, passes, and is gone.
Crime slinks from some dark alley nigh.
To fix on me its baleful eye.
Then, ever watchful, hurries by
To seek a more secluded spot,
My law—enforcing rays reach not.

An ambulance clangs by in flight;
Then silence and the pulse of night.
The winds that, moaning, ever seek
To voice their woe make awnings creak
Till every cranny seems to speak.
Blown, tattered papers past me wing . . . .
Thus all night long I sway and swing.

Walter G. Doty in *Edison Monthly*.



BERG'S SAVINGS CURVE

The interesting curve here shown indicates the savings that should be set aside annually to build up a fund which at the end of twenty years should support a person in comparative comfort. At the end of the 20th year the total amount saved plus the interest is $32,750.

The salary assumed is rather above that of the ordinary engineer. A smaller scale of ordinates will adjust the curve to his capacity.

The curve is worth keeping and the experiment of placing the annual point as close to the curve as possible is highly commendable.

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EDITORIAL

Due to unavoidable delay in publication any comment that may appear in the Editorial must always be several weeks out of date, so in place of the usual remarks on university affairs the Editor has taken the privilege of appropriating his allotted space to a discussion of several subjects in which interest should be more permanent.

The heresy committed in the Thoughts in the following pages may be unpardonable, but we will request our readers to forget for a while that they are engineers and that they will consider the ideas presented from the view point of an ordinary human being. May we hope that they will think before they condemn.

THOUGHTS OUT OF PLACE

By the Editor

EDUCATION FOR A LIFE OR FOR A LIVING?

Poets often write verses on the two souls in man, the sensuous and the psychical, the one in continual conflict with the other. Corresponding to these two antagonistic souls or conflicting impulses there are two types of success the one spelled $ucce$$ which provides a good *living* for the victor, while the other brings no physical comforts or delights but wealth of mind. Serenity, dignity, and composure mark the victor. Not power so much over others as power over oneself, not strength to coerce but strength to persuade, not external grandeur but internal splendor are the fruits of victory to him who makes a success of *life*. Education for a life should be our quest at college.

What constitutes life? We will say variety of experience and depth of feeling whether of pain or pleasure, delight or depression, and the products of a divine call to create and to rise certify to a full life. An expression of the feeling in art for the quickening of aspiring souls; a comprehensive generalization or law of science to quench the thirst for knowledge of those who wish to know causes and to trace the harmony in nature; a bridge, a canal, a locomotive to facilitate exchange remain as results to crown such a life.

Unfortunately, few such results follow the quest for wealth only. Nor does a rich man often appreciate the real feelings that bring forth these results. The commanding financier may own vast halls of art, but he seldom experiences the depth of feeling which existed in the hearts of the sculptors and painters who wrought the works on exhibition there. The humble poet or painter entering the halls receives the messages that the paintings and statues convey. He really owns the picture or the statue because the essence of the work is his. He it is who is thrilled with inspiration by a magnificent Apollo or moved to compassion by a groping Blind Flower Girl. The materialistic owner may claim the canvas and the paint upon it and the marble, but unless he is capable of receiving the feelings of the artist, the *painting* or the *statue* is not his. Not to own but to enjoy should be our aim.

Culture, as much if not more than training for a living only,

should be our quest at college. We owe it to ourselves. This does not mean that we shall become effeminate dilettantes. There is nothing effeminate in the man who lives completely. Refinement in place of coarse and cold might does not signify weakness. Wealth and variety of experience, a broad and sympathetic appreciation of the problems of human life denote manhood of a loftier type than that exhibited by the greedy ambitious aspirant for worldly rank.

Here at the University the opportunity for the development of a deeper appreciation of the fundamental in life, the beautiful and true is open to us. Even as engineers we are not excluded from this sacred privilege. There are many Sunday afternoons, many hours between classes that can be spent in quiet library corners. A consideration of every action with the question, "Is it worth while?" will reveal hours uselessly spent in idle talk, card playing, or at vaudeville performances. The busiest man is usually he who has most spare moments for reading. We are not beyond Poor Richard's maxims. "Be ashamed to catch thyself idle" may be looked upon with a haughty superior air as applicable to grammar school children, but a neglect of its dictum will track us down as well as them. Every day has twenty-four hours of which one-fourth of one hour daily applied to a search for the true and beautiful scattered as gems throughout the world of good literature will add a wealth to life that cannot be purchased by money or rank. Association with great minds is pervasive in its efforts, permeating us with great thoughts. A yearning to rise to their level grasps us and any spark of greatness that may be in us is fanned until it glows. Time spent with them is time spent to the best advantage.

To live as the great men have lived, the authors, scientists, and engineers should be our aim. To aid in the adjustment of an everchanging society, to study its problems and to charge with the reformer into the thick of injustice is a worthy ideal. To feel as the poet and to be able to rejoice in his visions, to think as the philosopher and to be able to travel with him in his journeys of the intellect are powers that can be cultivated at college. To the degree that we participate in these activities do we really live. Education that guides to such a life is true education.

LOYALTY

Like the word *efficiency* in the magazines and newspapers, on the campus there is no word heard oftener and used with less thought than *loyalty*. What does it mean? Perhaps most students will give their assent to the meaning expressed in the song so dear to the heart of all Illini, Loyalty. "We'll back you to stand . . . . ." *You* refers to the team. By some marvelous feat of mental gymnastics quite beyond the power of the ordinary reflective mind, team and university are sometimes identified, but the minds of these performers can seldom be approached and no attempt to do so will be made here. The honest interpretation of loyalty to the team as a team will be adhered to.

No attempt will be made to disparage this kind of loyalty. Nor is the purpose here to discuss the evils of intercollegiate athletics. The only question to be raised is, How shall we be loyal to our alma mater as an institution of learning?

Many persons answer this question by saying that there is nothing that advertises a university so extensively and so effectively as a successful team. Even a star player on a team or a track man is more efficacious in drawing men to a school than expensive advertisements in educational magazines, especially so since this person is brought before the young men who are possible candidates for the privileges of a university education. Through the daily papers this man's name and the name of the institution which he attends and honors reach just the men who are planning a college career. Even the Post or magazines of its kind count as readers only a fraction of the people who read the sporting columns of the newspaper. No one can dispute the validity of these assertions. The arguments seem strong in favor of the severely censured athletics. There is only one conclusion, everyone has long ago seen it, intercollegiate athletics should be encouraged and every effort applied to stimulate interest in it and to help in bringing here men who promise to become good athletes. This is loyalty. Cheer the men on the field, shout for the track man as he passes by you, help the hero in his class work, pay your seven dollars, and you are doing your alma mater a great service. Do all this, and you are loyal not only to your team, but through it to your school.

Loyalty as seen by these same persons does not stop when the four years are over. There are many home-comings and class

reunions in which it may exercise its wholesome influence long after graduation. An Illini Club can often direct a student athlete to the alma mater from which it derives its name. There is no excuse for any man, the opportunities for service are so manifold that every man can at some time or other promote the interests of the school from which he received so much. Your presence on the grand stand only once a year has its effect and will be appreciated. It shows the proper spirit.

As an alumnus of wealth, you can do vastly more. A building erected at your expense, or a fund donated toward the erection of a building such as a library or a museum shows loyalty on a much grander scale. It stands as a monument to your fidelity.

In outline this is the ethics of college loyalty. Again, as with many systems of ethics, it does not go far enough. We should ask: Are the men who read the sporting columns most conscientiously exactly the most desirable? Does the advertising reach the worthiest? If so, who are the worthiest? Further, are the time and effort applied to promoting the success of the team warranted by the results? In a word, what, after all, is the purpose of a university? The last question must be answered in order to arrive at a conclusion to the problem of loyalty.

The ideal upheld by many institutions, which the founder of Cornell defined as a place where any man may obtain instruction in any subject must fall. The university cannot afford to be a great melting pot in which a little gold is mixed with much lead to produce a valueless alloy. The gold should not be contaminated with the baser metals. The university should provide facilities and stimulations for those only who are properly qualified. If democracy must have education for all, then separate the wheat from the chaff, the gold from the lead, and let us put an end to adulteration. The properly qualified constitute, to be sure, only a small minority of all who long for that distinction "a college education." To seek for these few and to direct them to your alma mater is an expression of loyalty. These individuals may be interested in sport, even in intercollegiate athletics, certainly in personal athletics, but their interest concerns itself primarily with the legitimate function of the university, preparation for the world's work. Education for all must be restricted to education for those who are capable of receiving and applying it.

Usually such persons are not of the sporting column species. Their enthusiasm expends itself in production of the necessary

or desirable and destruction of the useless or harmful. Conscientious and well directed efforts mark their actions. An earnest determination to think and then to do distinguishes them. To train such men brings profit to the state's investment. They should be relieved from the parasite who is so easily attracted here and so cordially invited by the sporting column of the newspaper.

If the purpose of the university be to provide the means for the development of the properly qualified, then a return to the university in achievements constitutes the obligation of those qualified to their alma mater. To write, to build, to discover, to produce, and sometimes to undermine, bring honor upon a university. The team is not the university. No amount of yelling, no "seeing the team off," no loud mass meetings, no sacrifice on the part of an alumnus to attend a game ever wrote a word in a work of literature, laid a stone on the walls of a new building, discovered a law of physics, or helped to grow two blades where only one grew before. Why make pitiful appeals to alumni for donations toward laboratories, libraries, or museums when there are no scientists to perform investigations not even embryo scientists, book lovers to read, or students seeking information? Why import philosophers from Germany to deliver lectures before empty seats? Loyalty consists in using to the fullest extent the material supplied and in taking advantage of the opportunities for development offered, or if the interest is lacking, of leaving the university. Earnest application to study which is preparation for achievement is the undergraduate's first duty. Let loyalty flow into this channel and we shall cease vexing college presidents, and much censure will be diverted upon other institutions where it will be of service.

THE HOUR BETWEEN

Character has been said to be what a man is in the dark. The Hour Between is an hour in the dark. Not what a man does in class or for class, not what courses he takes or what career he is preparing for determines what a man is. What a man is is shown best by what he does during his spare moments when free from compulsion and relieved of the drudgery of routine work. It is then that we do what we like to do because we like it, and reveal what we care for more than anything else. Wheth-

er we play cards or read Plato, attend vaudeville or study the electron theory, the conclusion is always: this is what we prefer to do. As our choice is unhampered by any external forces our actions are an indication of our ideals. They show what we aim to live for.

A famous scientist in judging the merits of a candidate for a research scholarship made a special point of finding out what the person did independent of the dictations of his teachers. He paid more attention to the interest a man took in the subject under consideration by doing things that were not required than he did to the individual's scholastic records. The student who reads the technical journal not because he was told to do so by his instructor but because he wants to know what advancements are being made in engineering shows a quality of the true engineer. The agricultural student who reads Milton because he finds pleasure in reading has a better appreciation of literature than the L. and A. student who reads the same author under instruction. The science student who does nothing beyond that demanded by his professors and spends his leisure moments in frivolous amusement is not a scientist nor will he ever be one. The person who goes to church not because convention requires it, but because he has a craving for an hour of spiritual rest and inspiration is truly religious.

The Hour Between is the golden hour, the soothsayer and the confessor of our lives. It whispers an unmistakable warning or chants a hymn of victory. It is infallible in its verdicts. There is no higher court of appeals, its decision is final. You are, have been, and will be what it indicates.

The spirit of moving on is the spirit of progression, the spirit of optimistic dissatisfaction. It is necessary to cultivate restlessness in order to have a moving spirit. The fault and the fate of the rolling stone is not so much because it rolls as it is that it usually rolls down hill. When you move be sure of your direction.

WALTER C. KERR.

DEPARTMENT NOTES

E. E. SOCIETY

The last meeting of the E. E. society before Thanksgiving was held the evening of October 30, 1913. At this meeting the question of a partial affiliation of the E. E. Society with the local branch of the A. I. E. E. was discussed. As the motion was finally worded, this affiliation was in no way to change the organization of either society but merely to bring about a union in their meetings, thus giving both societies the benefits that might be derived from the various speakers. After considerable discussion the motion was amended to the effect that the affiliation should only be binding for one year. It was then almost unanimously passed. At present the A. I. E. E. has not taken any action on the matter but will probably do so in the near future. The speaker of the evening was "Doc." Matthews. His subject might well be broken up into two parts; first, "The Derivation of the Constant for Stress Effect," and second, "Peculiar Customs I noticed among the Europeans." As the first subject would indicate, it delved rather deeply into the mathematical realm, but the many intelligent questions which were asked showed that his audience was always following the speaker. The second half of his address was both interesting and instructive; only lack of space prevents further discussion of it here.

The speaker for the meeting held December 5, was L. W. Faulkner. His subject "Propagation of Electric Waves and their use in Wireless Telegraphy" was rather deep, but bright questions such as, "If you didn't use wire in your wireless antennae, what could you use?" served to amuse those who did not choose to follow him through his mathematical calculation.

No business was taken up at the meeting held December 18, but the address delivered by J. H. Miller, more than made up for the lack of business items. He talked on "Gas Power" and illustrated his lecture by a large number of lantern slides. According to the data he had at hand, gas is the cheapest source of power obtainable for plants designed to generate less than two thousand horse-power.

The E. E. Society picture was taken at noon on Wednesday,

December 10. As usual the Library entrance formed the background and photographer Strauch did the "shooting."

Two of the new nitrogen filled incandescent lamps have been on exhibition in the business section of Urbana. These lamps have a higher efficiency even than the old style tungsten lamps and at the same time are not much more expensive.

On the first of December, Mr. F. C. Loring left his position on the E. E. faculty and is now working for the American Elementary Electric Co. of Washington, D. C. His office for the present will be located in Champaign.

E. A. JAMES.

CIVIL ENGINEERS' CLUB

The student program feature has come to take a prominent place in the meetings of the Club. Some of the papers deal with the personal engineering experiences of the writers, others have been written up after study of engineering papers, etc. Following are some of the papers presented:

"The Use of the Divining Rod for Detecting Underground Water" by P. T. Reilly, '14.

"Chicago Track Elevation" by C. H. Thompson, '14.

"Double Tracking and Raising a 1000 ft. Bridge Under Traffic" Lantern Slides. By E. M. Lurie, '14.

"Proportioning Gravel Concrete" by F. T. Sheets, '14.

"A Journal of John's Journey" by J. E. Lewis, '14.

"Mountain Railroad Location" by W. M. Bonham, '16.

"Pile Bridge Construction" by W. H. Boyer, '14.

Papers by J. J. Woltman, '14, D. M. Riff, '14, C. I. Burggraf, '14, and others will be presented shortly.

Student talks have been interspersed with a number of lectures by prominent engineers as follows:

On November 7, Mr. T. L. Condron, C. E. of Chicago, came all the way from Detroit to present "Architectural Engineering and the Status of the Engineer". Some unique designs in cantilever floors and the various problems of reinforced concrete mill-building design were carefully explained and illustrated by means of lantern slides.

On December 5, Mr. G. H. Tebbetts, '99, Bridge Engineer of the Kansas City Terminal Railway, gave a very instructive talk on the work of constructing the Terminal. The lecture showed

what could be done by a far-sighted engineer and designer in making the structure not only useful but also artistic.

What promises to be not only an interesting talk but a useful one as well, will be given Friday, February 27, by Mr. J. H. Prior, Engineer of Design of the Chicago, Milwaukee and St. Paul Railroad System, on "How to Get Your First Job and Your Second One."

The C. E. Club now has a membership of 102, and is still growing. A decided impetus has been given the Club, through the securing of a new C. E. reading room. A petition for a new room was started last May and its consummation came in November. All that is needed now, is a nice rug and a few lounging chairs. The room is well filled at all times, and the fellows are putting their spare time to good use by perusing the department periodicals.

A start has been made on a C. E. Club data handbook, the loose-leaf sheets of which will be furnished to the members at the cost of blue-printing.

E. M. LURIE, '14.

M. E. SOCIETY

At the meeting of the A. S. M. E. held November 7, Mr. Benedict gave an illustrated talk on Facilities for Handling Work. President Aagaard urged any of those present who were not members to join at the close of the meeting.

On December 12, Professor Harding talked to the A. S. M. E. on the topic, Linoleum Plants, Operation and Design. Although he had never been in a linoleum plant before he was given the task of designing one, he evidently accomplished the feat very satisfactorily. He started with the proper selection of the location of the plant and carried it on through the construction of the buildings and the actual operation of the plant. Numerous views of the machines used, some of which he had to design, were shown. The plant when completed cost $2,000,000 and covered an area of 19 acres.

H. E. AUSTIN, '15.

RAILWAY CLUB

At the second meeting of the Railway Club, on October 17, Mr. A. F. Comstock of the Railway C. E. Department gave a

talk on Railway Signalling. The speaker opened the topic with a brief history of signalling, in which he mentioned some of the crude forms of signals which were first used on American railroads. The first signal consisted of a white and a black ball mounted on a mast. The white ball when raised indicating "clear" and the black ball "danger". The next signalling system to be used was the telegraph, which was first installed on the N. Y. C. R. R. to control the movement of its trains. The disadvantage of the telegraph dispatch system was that after a train had left a station, on a single track road, the opposing train would have to wait at the next side track until the first train passed by, no matter how long the delay. The telegraph was soon superseded by the "banjo" signal. This signal consisted of a colored disk which swung inside the banjo-box, in front of a circular opening. Although this signal was the best at the time of its installation, it had a great many disadvantages among which the most important were; the signal was small and difficult to see, also that the color-system was used.

These faults of the banjo signal led to the invention and installation of the lower and upper quadrant signal. The quadrant signal consists of an arm moving in a vertical plane through one quadrant of a circle. The horizontal position of the arm meaning "stop; danger" and the vertical position "proceed; track clear." The upper quadrant signal has begun to displace the lower quadrant instrument owing to the fact that if the former gets out of order, or becomes overweighted with sleet, it will drop, by its own weight, to the danger position; while the latter will drop to the clear position, under the same conditions.

The speaker finished the talk by showing illustrated views of the various types of signals.

On the evening of October 31, Prof. A. M. Buck, of the Railway E. E. Department, gave a very interesting description of the Features of Electric Traction. In this discussion the speaker pointed out the many advantages which arise from the use of electricity instead of steam on railroads. Among the features mentioned were, the use of an efficient central power plant to generate power instead of the many, small, wasteful plants which draw the steam trains; the cleanliness of the electric system also gives it a decided advantage over the other road, especially in passenger travel.

The next meeting was held on Friday, November 21. The speaker of the evening was J. A. Wilson, '14, and the topic discussed was Locomotives, American and Foreign. With the aid of many illustrations the speaker showed the peculiarities of the foreign locomotives as compared with our own. The absence of headlights and the use of an abbreviated engine cab, together with the location of the cylinders inside the wheels, were some of the interesting features mentioned in the talk. By an actual comparison of schedules it was shown that the speed of American passenger trains is greater than European trains. In fact there are only a few continental trains that have a schedule speed which can be compared with that of our famous eastern trains. The talk was closed with a brief description of some of the German high-speed electric train tests, in which a speed of 130 miles per hour was reached.

On December 5, Mr. R. B. Keller of the Railway M. E. Department, gave a talk on latest developments of the Safety First Movement. The growth of this movement, since its foundation in 1911, has been phenomenal. At first the railroads feared to make public the number of casualities that had occurred on their roads. However, the success of this educational movement on the Chicago and Northwestern R. R., proved to the American railroad owners that it was not only practical, but that it was a money saver. The protection of machinery, the distribution and posting of bulletins, together with the use of illustrated lectures has served to decrease the number of railway accidents from twenty to fifty per cent. The value of this movement becomes apparent when one considers that over eighty-five per cent of the people killed annually on railroads are employees, and that sixty per cent of these accidents occur when the men are not on duty.

The industrial world has followed closely in the footsteps of the railroads until, at the present time, every manufacturing plant of any size has a force of men whose duty it is to protect their fellow workers from all possible injury.

J. M. Fetherston, '14.

Railway Department Notes

Professor E. C. Schmidt, head of the Railway Department, has been in Washington, D. C., serving as an examiner on the

Civil Service Commission for candidates for the Board on the Valuation of Railways.

Professor A. M. Buck has been appointed a member of the Committee on Education of the National Electric Railway Association.

Illinois-Central Locomotive 958 is still in the Locomotive Testing Laboratory and tests are being run every day. These tests are to show the performance of the locomotive under various conditions and positions of the throttle and reverse lever.

E. M. KRABBE, '14.

MINING DEPARTMENT

The Danville *Bulletin* of the Illinois Coal Mining Investigations is now in the hands of the printer. It is the first of a series of reports which will include a complete study of the conditions under which coal is mined in this state. The State was divided into nine districts for the purpose of investigation and the results which have been obtained in each district by the geologists, engineers, and chemists will be published from time to time. These bulletins including reports on special subjects and summaries for the entire State will supply much new and comprehensive information concerning the mining of Illinois coals.

Mr. R. Y. Williams formerly of the U. S. Bureau of Mines has been appointed Director of the Illinois Miners' and Mechanics' Institute which was provided for by the following act of the State Legislature:

"An Act to prevent accidents in mines and other industrial plants and to conserve the resources of the State by the establishment of the Illinois Miners' and Mechanics' Institutes and for the administration and support of the same.

"Section 1. Be it enacted by the People of the State of Illinois represented in the General Assembly: That in order to prevent accidents in mines and other industrial plants and to conserve the resources of the State by the education and training of all classes of workers in and about the mines and other industrial plants of the State there shall be established and maintained a form of educational betterment work, which shall be known as the Illinois Miners' and Mechanics' Institutes.

"That it shall be the purpose of such Illinois Miners' and Mechanics' Institutes to promote the technical efficiency of all persons working in and about the mines and other industrial plants of the State and to assist them to better overcome the increasing difficulties of mining and other industrial employments. In the development of this purpose, any and all means may be employed which promise to give desired results such as bulletins, traveling libraries, lectures, correspondence work, classes for systematic instruction, or meetings for the reading and discussion of papers."

Formerly two to three lives have been lost annually for every 1,000 miners employed and the number of serious injuries has been much greater. The Illinois Miners' and Mechanics' Institutes will do much to reduce this high accident rate. Thirty thousand dollars was appropriated for this work which began January first, under the supervision of the Mining Department of the University.

Mr. K. D. White who was formerly with the State Geological Survey has recently returned from Venezuela, South America, where he has been prospecting and locating petroleum fields for the Barber Asphalt Company.

S. T. WALLACE, '15.

The true purpose and value of engineering activity lie in providing better and easier ways for satisfying ordinary human needs. This provides more leisure and opens new possibilities for a higher spiritual and intellectual development of humanity.

VLADIMIR KARAPETOFF.

The Technograph

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The Technograph

Vol. XXVIII March, 1914 No. 3

THE STATUS OF RAILWAY ELECTRIFICATION

BY A. MORRIS BUCK

Asst. Professor of Railway Electrical Engineering

It is nearly twenty years since electric power was first applied to the operation of railway trains under trunk line conditions. The unquestioned success of this enterprise led many people to believe that a general adoption of electricity would soon follow, and that the steam locomotive would be replaced by the electric motor. To some it is a matter of surprise that this prediction has not been fulfilled. At the present time it is well known that electrical equipment can be designed to operate better and more efficiently than the corresponding steam equipment; but the railways have been exceedingly slow to consider the use of such apparatus. That there must be some reason for this attitude of railway officials is evident; but the reasons are not at all apparent to the casual observer. It is interesting to investigate the situation, and to determine whether the viewpoint of the railway man is justifiable.

The purpose of any common carrier is to transport passengers or freight from point to point with a maximum of safety, of speed, and in the case of passenger traffic, of comfort. For many years the steam locomotive has furnished a means of accomplishing all these things with a reasonable degree of satisfaction. The steam locomotive has characteristics which are excellent for heavy railway service. It is unique among motive powers in that it comprises in itself a complete power plant. The power of a locomotive is dependent on two principal factors: the capacity of the boiler for producing steam and the ability of the cylinders to use the steam thus produced. At slow speed the tractive effort or draw bar pull that can be developed depends on the average pressure of the steam against the piston. If designed

with cylinders of large size the pull may be further limited by the adhesion between the driving wheels and the track. This maximum pull may be developed at a constant value almost independent of speed so long as the boiler is able to supply steam to the cylinders. Since the number of

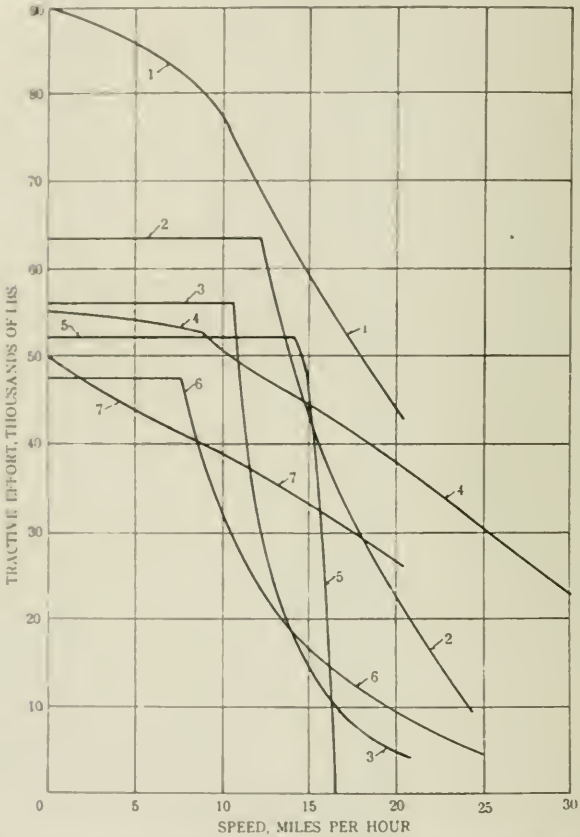

FIG. 1. TRACTIVE EFFORT OF TYPICAL FREIGHT LOCOMOTIVES

1 Mallet Articulated, Southern Pacific (Steam)
2 Single Phase, Boston & Maine (Electric)
3 Direct Current, Michigan Central (Electric)
4 Mallet Articulated, Great Northern (Steam)
5 Three Phase, Great Northern (Electric)
6 Single Phase, Grand Trunk (Electric)
7 Consolidation, Great Northern (Steam)

strokes of the piston, and, therefore, the amount of steam used, varies directly with the speed, a point must be reached where the boiler cannot maintain full pressure against the increasing demand for steam. To reach higher speeds a smaller amount of steam per stroke must be used so that the mean

effective pressure is reduced and with it the tractive effort. This is accomplished by "notching back" the reverse lever so that steam is only supplied a small portion of the stroke. For all speeds above this limiting value the work done by the locomotive depends almost entirely on the capacity of the boiler for supplying steam. Certain slight variations in the performance may be obtained by the fireman shoveling a little more coal or by the engineer conserving the steam by judicious use of the throttle and reverse lever. Such variations are of only small magnitude. The relation between tractive effort or draw bar pull and speed for some typical freight locomotives is shown in Fig. 1, and for passenger locomotives in Fig. 2.

The steam locomotive can thus be seen to have rather definite limitations as regards output. Since the cylinders depend for their supply on a boiler of limited capacity their performance is hampered. In its turn the boiler is dependent on the fire box and the ability of the fireman to keep it properly supplied with fuel. Due to the demand for units of greater power and the necessity of getting maximum capacity per unit of weight the performance is forced considerably beyond the most economical operating point. That this is so may be noted by anyone observing the large quantity of cinders discharged from the stack. Tests show that about one-tenth of all the coal fired is discharged in this manner. This waste is a direct result of the necessity for the heavy draft used to burn the required amount of coal. In locomotives working under load the draft is often so great that large particles of coal are lifted bodily off the grate and carried up the stack. Burning the coal in this manner is admittedly inefficient, and the amount used per unit of work done by the locomotive is greatly in excess of that required in good stationary practice. Although it may be possible by special precautions, or by the use of special high-grade fuels, to reduce the amount of smoke produced, it is in general impractical to do so. Since the entire power plant, and with it a supply of fuel and water, must be hauled in addition to the train, there is a distinct loss of efficiency from that cause.

A number of devices to improve the performance of the steam locomotive have been introduced within the past few years. One of the best known of these is the superheater, by means of which the ability of the steam to do work is increased. By its use the capacity of the locomotive at the higher speeds may be

materially improved. It carries with it, however, a need for more careful attention and maintenance.

An interesting development of the demand for high-powered units, is the Mallet articulated locomotive. This consists of two complete sets of cylinders and driving wheels, upon which is mounted a flexible boiler, enabling the engine with its long wheel-base to go around curves of moderate radius. Although it was predicted that the use of the Mallet locomotive would solve some of the hardest problems of the railroad, it is significant that very few engines of this type were built during the past year. At the present time it does not seem that it will find a very extensive field of application. In a number of the largest engines the capacity has been limited by the ability of the fireman to handle

DIRECT CURRENT ELECTRIC LOCOMOTIVE, PENNSYLVANIA RAILROAD

coal. Several types of mechanical stokers have been designed to do this work more efficiently. If they prove entirely satisfactory one of the limitations of modern locomotive design will be removed.

A number of incidental features are characteristic of the operation of steam locomotives. The ordinary engine run is from 100 to 150 miles long. This distance has not been determined arbitrarily, but represents the maximum distance which a locomotive can run without attention. At the end of the run the fires must be drawn, the tubes blown out, and in case the water used in the boiler be bad, as frequently happens, the boiler must be washed out. All the working parts must be given a thorough inspection, and any necessary repairs made before the engine is

ready for further service. Stations for the supply of water, and in some cases for coal, must be located at convenient points along the route. Previous to being sent out on the road fresh fires must be built in the fire-box; and it usually must be made ready from an hour to two hours before actually required. A considerable amount of fuel is wasted in order to have the engine available for service. Owing to the large area of exposed surface of the locomotive, there is a considerable loss due to radiation, especially in cold weather. In some cases radiation losses are so great as to reduce the capacity of the engine in winter time. Cases of extreme cold have been known to prevent entirely the operation of locomotives. Every year or two the engine must be sent to the repair shop for a thorough overhauling. To do all these things roundhouses, shops and workmen must be provided.

It is about the steam locomotive that the entire structure of our trunk line railroads is built. An attempt to use some other motive power may have results which cannot be contemplated merely by the substitution of one form of locomotive for another. The benefits to be derived must be quite marked before a mechanism which has given such good service as the steam locomotive will be discarded. It is well, therefore, to examine the possibilities of electricity as a motive power before attempting to pass judgment on its well-established competitor.

The advantages of electric power depend primarily on the application of the physical characteristics of electricity to the locomotive. As ordinarily employed it must be developed from the heat of burning fuel or from the energy of falling water. Such energy is transformed through suitable apparatus into electric energy and as such is transmitted over wires to the motors which operate trains. The comparatively simple structure of the steam locomotive is replaced by the somewhat intricate system necessary for generating and distributing the electric energy; but the separation of the power plant from the locomotive makes possible a material simplification of the latter. By the use of this system as employed in modern transportation, a number of advantages may be obtained. These may be roughly divided into advantages of a physical nature, and those which are financial in character. Of the former the most important is the gain in capacity which is made possible. The electric locomotive is not subject to the physical limitations that hamper the steam engine. An electric locomotive consists essentially of one or more electric motors

and means for controlling them. The entire structure may be made much simpler than when the power plant has to be carried about. The running gear can be so proportioned as to provide the best possible support for the motors. The weight to be carried is reduced to a minimum, and the entire structure can be made more compact. Since the number of essential parts is much reduced, the design of the locomotive can be considerably simplified. On account of the greater simplicity the wear is less, and the cost of maintenance lower. Modern electric locomotives are so arranged that two or more can be coupled and controlled from one position, so that a single driver can efficiently operate them as a single unit. This is especially good as compared with the operation of two or more steam locomotives together. In the latter case it is almost impossible to get the machines to operate exactly together, making them less efficient when handled at the front of a single train. By having the electric locomotives subdivided as suggested, it is possible to choose the proper locomotive capacity for each train. This obviates the necessity for sending out engines capable of pulling trains of 3000 to 3500 tons with trailing loads of from 1000 to 1500 tons, as is often done in steam service.

In Fig. 1 and Fig. 2 are shown tractive effort curves for some representative electric locomotives in comparison with steam locomotives for similar service. It may be noted that all types of electric locomotives maintain their maximum tractive effort up to higher speeds than do the steam locomotives. For this reason they are able to pull their maximum loads at considerably greater speeds than is possible with steam power. The advantage of being able to couple electric locomotives together may be seen by comparing locomotive No. 1 (steam) with locomotive No. 6 (electric) in Fig. 1. By coupling two of the latter together, the combination will give about the same draw bar pull (tractive effort) as the former, which is one of the most powerful Mallet engines, designed for heavy mountain service.

In some cases it is not even necessary to provide locomotives for electric service. Since the motive power equipment is so simple, it may be placed on the trucks of the individual cars, thus securing a maximum weight efficiency. So far, this method has been employed only for passenger service. It is exceedingly doubtful if motor car trains will ever be used for the haulage of freight. The use of motor car trains makes possible higher-

accelerations; and for passenger train service may give better results than possible with locomotives. This is especially true of suburban train service.

To secure these desirable results, a railroad must be equipped with the complete generating, transmitting and distributing system for the electric current needed to operate the trains. In reality, this introduces but little complication. The equipment is all standard, being practically the same as that employed for ordinary

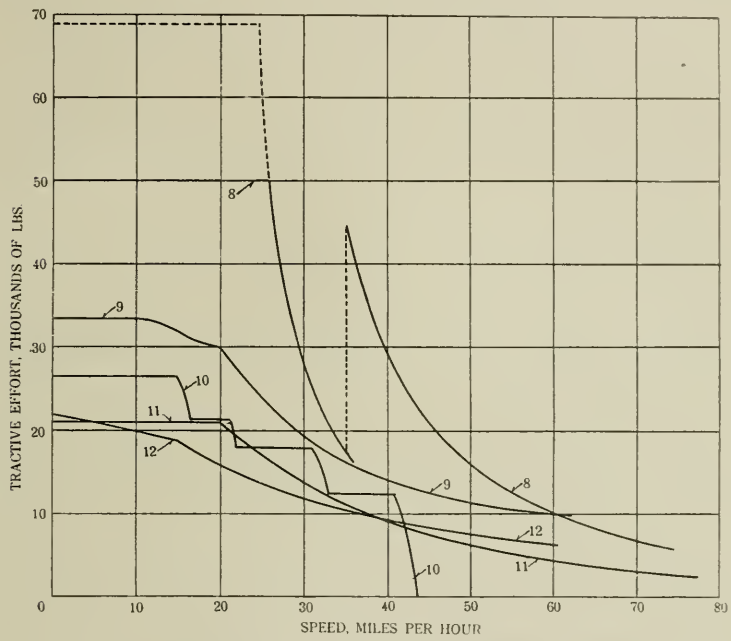

FIG. 2. TRACTIVE EFFORT OF TYPICAL PASSENGER LOCOMOTIVES

8. Direct Current, Pennsylvania (Electric)
9. Pacific, New York Central (Steam)
10. Three Phase, Swiss Federal (Electric)
11. Single Phase, New York, New Haven & Hartford (Electric)
12. Atlantic, Pennsylvania (Steam)

lighting and power installations. In fact, a number of electric railroads own no power plants, but purchase power from the same machines that are supplying electricity for the operation of lights and stationary motors. Modern electric equipment possesses a high degree of reliability. The chance for trouble in the entire system, including all parts from the coal pile to the locomotive, is much less than in the case of the steam locomotive alone. Without question the electric system is more reliable than steam. In cases where roads have been electrified, the delays

due to the motive power have been reduced to not over one-half the number and duration incident to steam service.

The advantages we have been discussing are largely in the nature of increased capacity. It is to increase the ability of a road to handle traffic that electrification has been adopted in all the installations so far made in America. There is another reason for the adoption of electric power which will be of increasing importance as the ability of electricity to handle trunk line problems becomes better understood. This is the reduced cost of operation which follows an intelligent application of electric power. In order to be a financial success, the installation must show operating costs enough lower to pay interest on the added investment, and some additional return to the stockholders who have assumed the risk of the undertaking. The physical advantages of electric operation all tend toward lower costs, and in many cases the difference will more than care for the interest on the investment. The adoption of electric power for trunk line roads has in some cases been followed by an increase in the gross earnings. The greater flexibility of the electric system makes possible a better service, both for freight and passenger traffic; and this is likely to increase the amount of business handled by the road.

It must not be taken for granted that every road can show attractive savings by the adoption of electric power. The investment is considerable in any case, and a large part of it is in the permanent structures, such as the power plant and the transmission and distribution systems. These items will be about the same in initial cost whether or not the traffic is heavy. With heavy traffic the trains can be spaced fairly well throughout the entire day, so that the capacity of the system is used to better advantage. Lines of considerable length, on which the traffic is dense, will, therefore, offer the best opportunity for the electrical engineer. The most satisfactory results can be obtained when an entire locomotive division can be converted to electric operation at once. In such an event the operation need be but slightly modified for the electric division. Steam locomotives released by the substitution of electric engines can be transferred to other divisions. In that way a minimum amount of investment need be made at one time.

Another case where electrification may be profitable is that of the trunk line railway in mountainous territory where water

power is available, and where the cost of fuel is relatively high. It is significant that one of the important transcontinental lines under such conditions has already committed itself to the immediate electrification of nearly 500 miles of main line track. No doubt other roads will follow if the results obtained in this installation come up to the estimates.

Electric operation has been shown to be practical, both from a technical and from a commercial standpoint. The fact still remains that the number of really important electrifications already attempted is few. There seem to be two important reasons for this. One is the natural conservatism of the railroads. While it is satisfactory to the engineer to see the results worked out on paper, the financier desires to have actual working examples before he is willing to invest his money in what seems to him a questionable enterprise. No doubt the success of one installation will make the second easier; and the result is likely to be cumulative.

The other important argument against electrification is in a way paradoxical. Due to the possible combinations of electric circuits, there are at the present time three rather well-defined methods of distributing electrical energy to moving trains: the direct current, the single-phase alternating current, and the three-phase alternating current. All of these methods have been used with considerable satisfaction for the propulsion of heavy trains, both in the United States and abroad. No general agreement has been reached by engineers as to which is the best "system" of the three; and commercial competition has still further clouded the issue. Each method has good points and bad. Any of them can produce results which are highly satisfactory, and the costs of installation and of operation do not vary widely. A greater coöperation among manufacturers would undoubtedly lead to an earlier adoption of electric traction in the cases where from careful estimate it would appear to be satisfactory. The field where electricity may be advantageously applied is large, and will increase with higher fuel costs. Once the conservatism of the investor is overcome, the application of electric operation is sure to broaden, so that within the next fifty years we may see many miles of trunk lines served exclusively by electric power.

SOME NOVEL INSTALLATIONS OF INDIRECT LIGHTING

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(The third and last of the series of articles prepared for THE TECHNOGRAPH on this subject by Mr. James—The Editor.)

In two previous articles in THE TECHNOGRAPH the writer has dealt with lighting problems along strictly technical lines. In the first of these articles, the general subject was treated in simple terms and analogies in an effort to show what constitutes good illumination; in the second the use of the indirect system was discussed from the standpoint of the principles previously explained.

FIG. 1. Congress Hotel, Chicago (Louis XVI Dining Room).

It was here shown that this system combines a very fine quality of lighting with a surprisingly high efficiency or economy, cases even being cited where, with similarly satisfactory illumination obtained by indirect and direct lighting, the necessary expenditure for electricity was lower with the former system. The necessity for high efficiency reflectors and for a light ceiling was also discussed.

A reasonable criticism of indirect lighting for many cases has been the lifeless appearance of the fixtures. Quality of illumina-

tion is always an important consideration but in some places such as in homes and in restaurants more than good lighting is desired. To meet this demand a number of artistic indirect units have been developed as shown in the photographs accompanying this article, which fixtures or containers for the lamps may be classified under three heads,—novel opaque bowls by construction or decoration, cove lighting and luminous fixtures.

Fig. 2. A novel adaptation of the indirect fixture.

Of the three classes, the first two depart least, in construction and results, from the generally accepted ideas of indirect lighting, requiring as they do an absolutely hidden light source. Examples of the first class are shown in the Congress Hotel (Chicago) dining room (Fig. 1) and in the enclosed porch (Fig. 2), and of the second class in the North Chicago Church, (Fig. 3).

Either the Congress Hotel dining room or the porch view must be seen to be fully appreciated. In the Congress the wall-brackets are for decorative effect only, the illumination for the room being secured from lamps concealed in the ornamental pedestals. The reflectors in use with each lamp are necessarily of special design so that most of the light rays will be directed to the ceiling and then back to the tables and incidentally to the walls, rather than first to the walls where they would be reflected to the ceiling and other walls and become unavailable for useful illumination. Any manufacturer of indirect fixtures, however, is in position to recommend and to supply proper reflectors, provided he is given the necessary information relative

FIG. 3 Church of the North Chicago Hebrew Congregation. (Showing Cove Lighting).

to room dimensions, decoration, etc. The choice in this case is particularly effective, combining with the general design of the installation to give the room the name of being one of the most beautifully illuminated interiors known. The scheme suggests numerous possibilities such as the extension of newel posts, book cases, etc. A further important point is the possible use of the pedestals as flower urns or for other purposes when decorating.

The arrangement of the porch fixture (Fig. 2) is evident. If necessary, a special container may be used to protect the plant from the heat of the lamp. The idea is both simple and novel.

Cove lighting, of which Fig. 3 is an illustration, is really a forerunner of the indirect system as now known. The lamps and reflectors are concealed in coves about the sides of the room or the dome to be lighted. The type of reflectors used must be determined by the conditions encountered and the results desired. For instance, it may be that the ceiling is to be lighted at a uniform intensity, requiring two or three types of reflectors set at

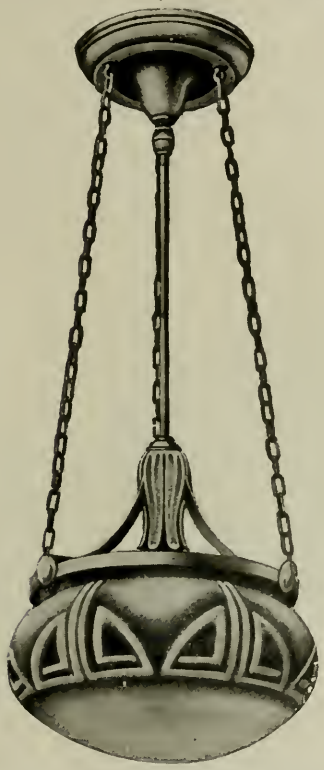

Fig. 4. A Single-unit Luminous Bowl Fixture.

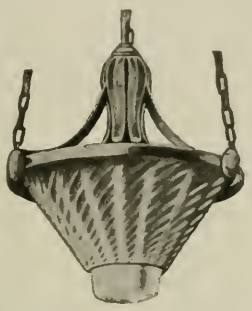

Fig. 5. Reflector and Diffuser for Fixture in Fig. 4.

different angles, or it may be that some special feature in the decoration is to be emphasized in which case no better way could be found than by an adjustment of the illumination. The cove arrangement is particularly effective in domes or high and elaborately decorated ceilings, but is not so good as the indirect fixture for small rooms.

The luminous type of fixture, listed in class three, is being placed on the market in a number of forms and is meeting with popular approval. Table or art lamps, later referred to by the trade term "portables", are distinctive and will be considered separately. Of the pendant types there are two general classes, semi-indirect and luminous bowl, the former being merely an inverted glass bowl claiming the advantage of the indirect fixture because the ceiling is lighted but making no effort to control the rays or to direct any large part of them to the ceiling. This class is, therefore, but a modified form of direct lighting, being very similar to the opal globe or hemisphere. It

merits its popularity in its low first cost and in the protection of the eyes from the bright filaments of modern lamps.

The luminous bowl fixture is a trade term applied to those fixtures using the indirect system entirely so far as useful lighting is concerned, but introducing some device whereby the glass in the

FIG. 6. A Multi-unit Luminous Bowl Fixture.

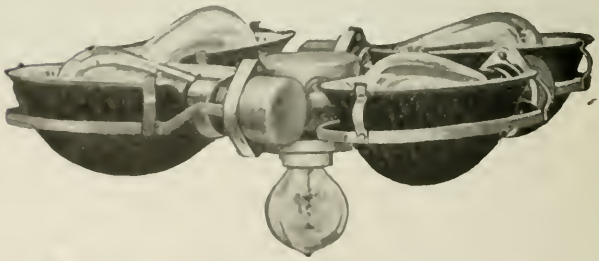

FIG. 7 Interior Equipment for Fixture in Fig. 6. (Showing small lamp).

containing bowl is illuminated. It is capable of all the possibilities of the semi-indirect unit, but has all the advantages of true indirect lighting in addition. It is likely to be more expensive than the semi-indirect fixture because it must contain the character-

istic high efficiency, opaque reflectors of the indirect system, as shown in Figures 4 and 7. Figure 5 shows the manner in which the bowl is lighted where a single lamp is used, the small por-

Fig. 8. The Hub, Chicago (Main floor).

celain cup being so designed that the rays passing through it are distributed over the interior of the fixture. This cup is at the

extreme bottom of the reflector and under the lamp, so that the efficiency of the unit is not materially changed by its introduction. The interior equipment for the multi-unit fixture of Figure 6 is shown in Figure 7. The small pendant lamp consumes about ten per cent as much power as all the rest in the fixture, even this amount is saved as much as it would be in the semi-indirect type.

Figure 8 shows a representative installation of the multi-unit luminous bowl type of fixture in the new Hub in Chicago. In this case, as in all others considered in this article, the photo-

FIG. 9. The Luminous Bowl in the Home.

graph was taken by the light from the indirect system alone. The excellent distribution of light secured is shown by the absence of pronounced shadows, even where they might be most expected. A night photograph requires a long-time exposure, and still no halation is apparent about the fixtures in this room, showing that while the bowl is well lighted, it is a very secondary source, the useful illumination coming almost entirely from the ceiling as previously suggested.

Indirect lighting is nowhere so effective as in the illumination

Fig. 10. A Bed Room Installation.
Fig. 11. Tea-Room, Hyde Park Hotel, Chicago.

of the home. When carbon lamps were in use people were inclined to install anything which would give light at a reasonable cost, without regard for the quality of the illumination secured or for the appearance of the fixture. The new high efficiency lamps have not only made better systems possible for all, but the brilliancy of their filaments is making eye-protection a necessity. Several illustrations are given in connection with this article where indirect lighting has been used to good effect in this class of interiors. Figure 2 shows an enclosed porch with a special arrangement

FIG. 12. The Table Portable in the Home.

of the standard fixture, Figure 9 shows a dining room and living room and Figure 10, a bed room where luminous bowl fixtures are used, and Figure 12 shows an installation of the art lamp which is described later. In each case the result is suggestive of comfort—almost luxury. This suggestion is largely responsible for the popular conception of the expense of indirect lighting, the truth being that it is frequently less expensive than a similarly adequate installation of direct lighting would be and that, even where it may be slightly more costly, the results justify the expense.

Figures 11 and 12 show two styles of the "Curtis Portables" or art lamps which are being placed on the market by a Chicago firm. These are not ordinary art lamps although the silk shades are not more brilliantly lighted than is true in the case of those almost useless ornaments. Here, however, the shade conceals an equipment consisting of a high power lamp enclosed in an opaque, mirrored reflector, and the real illumination in the room comes from the ceiling as in all other installations of the indirect system. The shade is lighted by three very small frosted lamps, controlled by a separate chain switch. The small lamps may thus be used alone, if desired, to produce a fireplace glow in the room, the entire unit may be used as an unusually efficient art lamp, or the large lamp may be used alone to provide excellent illumination from a concealed light source, the standard appearing as an ornament only.

In concluding this series of articles the writer desires to repeat what was said in the beginning. Indirect lighting is not the only system which can produce good results and the particular indirect lighting discussed in this and previous articles is not the only system passing under the idea of providing light by indirect means. However, a fair investigation will convince anyone that some kind of indirect lighting is both desirable and practical, in this day of high-efficiency and high power lamps, and also that the system explained here makes the greatest possible use of the principles of indirect in order to secure the best possible results. Most people have very definite ideas as to the relative economies of the several systems,—it is as manifestly unfair to compare costs in this case as to compare the prices of cottons, silks, and linens. Everyone cannot afford to wear silks, some cannot afford to buy the best system of illumination, but so long as the difference remains as slight as at the present, very few are justified in having anything but the best for the purpose for which they wish to use the light. No one system is always the best, each case has conditions peculiar to itself and requiring special consideration in determining the kind of lighting to be used. Illumination is a science which has sprung into being because of the necessity for eye-protection. If these articles have served to awaken interest on the part of the readers of The Technograph in the important subject of proper illumination, to convince them that there are advantages in the various systems which are worthy of careful consideration, it has accomplished its purpose.

PSYCHOLOGY AND BUSINESS

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Instructor in Psychology

For more than three decades psychologists have been quietly at work in their laboratories on the continent of Europe and of America discovering facts and laws concerning the mental life. These results have been published in scores of periodicals dedicated to the exclusive use of the science and in hundreds of systematic treatises, text-books, and monographs. The purpose of all of this labor has been, as a rule, single and definite: to discover mental truths. This singleness of purpose and the quest of fact are, indeed, characteristic of all scientific research and finds recognition, unfortunate in its connotation as it is, in the rebuke, so often administered by the layman to the man of science, that he lacks practicality. This is not the time nor the place to enter a protest against the accusation. While it is true that the application of the facts of science to the needs of daily life often furnishes a wholesome check and not infrequently contributes a healthy impetus to the activities of the scientist, it is, nevertheless, equally true that the aim to be practical is not inherent in scientific procedure. In this fashion, then, has the science of psychology gradually evolved facts and laws of mind quite independently of their immediate value outside of the science.

Now it has come about, as in the case of many other sciences, notably in such sciences as physics and astronomy, that soon after their discovery the facts of the laboratory have been found useful in other disciplines. Education was not slow to see in the form of the "learning curve" and in certain laws of the adequacy of sensory impression a real contribution to its own field. Medicine soon found material for the advancement of therapeutic practice in the laws of association and in the effect of emotions on the physiological organism. Religion has gained scientific endorsement for much of its dogma from the discovery of the laws of suggestion and from many phenomena of the abnormal mind. It is not surprising, therefore, that the demands of our industrial life should now make themselves felt; it is remarkable that business has not availed itself of the discoveries made in the psychological laboratory before the present decade. For a long time not a few industries have required a physical examination of their employees; but they have neglected to inquire whether these em-

ployees are mentally capable. Naturally the mentally unfit were either discarded when they made application for positions on the basis of crude earmarks and under the practised scrutiny of some representative of the employer, or more frequently they were gradually eliminated in the course of their apprenticeship because the casual inquiry of the examiner had not detected serious deficiencies of mental capacity. In either case economic waste resulted, first because the employer's representative was himself inefficient as a selecting agent in that his casual discrimination may have barred good material and admitted poor material, and secondly because the poor workman, once admitted, drew pay for work which was not worth the money, because he was introduced into an industrial machine where he acted as a dead weight.

In several lines of industry psychological tests of a sort have been introduced, such as tests for color-blindness among railroad engineers and tests of visual acuity for ship-captains. But we are now on the eve of a general demand coming, on the one side, from the great businesses for tests of a higher order, tests for types of judgment, quickness of apprehension, rapidity of motor execution, efficiency of memory for various details, tests by means of which the fitness of the applicant for a particular position can be determined, and of an urgent request, voiced, on the other side, by those interested in vocational training, for psychological anaylses of the requirements of the various kinds of employment. The slogan of this movement is, then, "the psychologically right man for the psychologically right place." Instead of a perpetual drifting of men and women from one type of industry to another until they "find" themselves, instead of a wasteful and disastrous dropping by the wayside, instead of a consumption of time, energy, and capital of business enterprises in the service of a useless apprenticeship, the psychological requirements of a position will soon be analysed, tabulated, and classified, suitable tests of applicants will be instituted, and an increase of efficiency will result.

And it does not seem to be too much of a divergence from rational conservatism to put these verbs in the future tense, for, without a mis-statement of fact, many of them could be written in the present. A street railway system in one of our larger cities, several telephone companies, a large steamship organization, a manufacturer of ball-bearings, and scores of other industries have already consulted psychologists with this particular end

in view. The characteristic qualifications needed for each one of these occupations has been or is being analyzed for the sake of extending scientific management to its logical conclusion with the analysis of mental functions. The psychology of advertising and of salesmanship have also received the attention of the laboratory and the results have been published in monograph form.

A concrete example of an experiment which has actually been performed in the Harvard psychological laboratory with street-car motormen acting as observers would doubtless best illustrate the feasibility of an analysis of mental processes involved in the performance of industrial labor. It was the aim of the psychologist to reproduce as accurately as possible the problem which presents itself to the motorman and at the same time to arrange the experiment so that various factors could be isolated and kept under control. He finally thought out a scheme which, in the opinion of all of the motormen who subjected themselves to the experiment, fulfilled the requirements of the situation as nearly as possible. He says, "The tried motormen agreed that they really pass through the experiment with the feeling which they have on their cars."

The plan of the experiment was briefly as follows: The track was represented by two heavy lines one-half inch apart passing lengthwise over a large sheet of paper. The paper was ruled into one-half inch squares. The squares which appeared on either side of the track were filled in an irregular fashion with figures 1, 2, and 3, printed in two colors, red and black. Figure 1 represented a pedestrian proceeding at the rate of one unit-square in a given unit of time, 2, a horse moving twice as fast, and 3, an automobile going three times as fast. Whenever these figures appeared in red, the direction of procedure was toward the track, whenever a black figure appeared, the direction was parallel to or away from the track. A red 3 two unit-squares away from the track would, of course, land on the track, a red 2 two unit-squares away would be out of danger. Over this paper a black velvet belt was made to pass at a speed governed by the observer, *i. e.*, the motorman. This belt had a slit long enough to expose four squares on either side of the track and wide enough to disclose but one row at a time. The observer turned the belt at a speed which was carefully recorded and reported those numbers in each successive row which would require a stopping of the car in order to avoid accident. The number of errors was then computed

and the various rates of travel of the belt were recorded. By applying the proper modulus to each one of the several factors, a grade was determined for each observer.

It is not very difficult to find flaws in the procedure. In the first place, all of the physical conditions were not exactly reproduced. Pedestrians, horses, and automobiles are known not to go at uniform rates in the vicinity of street-car tracks: that fact alone causes a large percentage of accidents. Nor are approaching obstacles always as clearly seen as are the figures. Then, other physical conditions make the situation much more complex: distracting noises occur, cars pass on the other track, time must be made up, snow and rain cause the brakes to fail, the psychophysical organism is fatigued, worried, chagrined, subject to scores of uncontrolled influences. In the second place, the mental attitude is much different. The examination in the laboratory must needs be competitive, a high degree of attention is given during a comparatively short interval to the problem at hand, the results in case of error are much less serious in each individual instance, and the entire performance is much less habitual.

In spite of these positive objections, we must remember that the observers claimed a similarity of experience under the two sets of conditions; they found the two problems very much alike. We have further to note that the graded results obtained from this experimental examination corresponded favorably with the actual records of the motormen during their employment with the street-car company. Specifically, motormen with bad reputations for carelessness and number of accidents for which they were responsible, obtained comparatively poor grades in the examination. What rôle suggestion plays in investigations of this sort is not known; but even with this interpretation, the fact remains that the same lack of confidence or the memory of past mishaps would be as potent a factor in actual life as in the laboratory. In both cases the memory of a long line of failures would be effective: it is a platitude, of course, that this condition is largely held responsible for many failures in life. On the other hand, men with clean records with the company made, as a rule, good grades in the tests. We have, then, a point-for-point relationship established between the record of the experiment and the standing in actual experience of everyday life. Another way of meeting some of the objections raised in the previous para-

graph lies in the consideration of experimental conditions. No experiment in whatever science performed aims to reproduce *all* the conditions of everyday life: in this respect no investigation actually copies real life in all of its objective and subjective relations. For its own convenience and because it would be impossible to investigate phenomena in their chaotic complexity, science isolates the conditions, and subtracts from the environment of disturbing influences. We must waive, then, the right to pass this sort of negative criticism. The experiment described was but a beginning; other experiments covering other conditions not controlled in this procedure can be, or, doubtless, are being, devised. Ultimately, when the counts are in, we shall have an experiment which corresponds as closely as possible in all points with the conditions of everyday life.

This instance of an experiment which was framed to meet the needs of business is but one of many such experiments which have actually been devised and performed with creditable results. To *medicine, religion, law, education,* and the *musical arts,* must now be added *business* as a claimant for facts concerning the mental aspect of the individual. And this sort of stimulus from without cannot do anything but good to the science of psychology in that new problems are raised, new interpretations demanded, and modifications of old views required. But with all of this progress, it is not safe nor sane to judge a growing discipline too quickly or too harshly; there are as many awkward movements in psychology as there are in a child during adolescence, and with the same amount of embarrassment. It is better to criticize the goal and general orientation, the progress made so far, the promise of development in the future, and the industry of the men who are endeavoring to open up a lead from which past generations failed to obtain gems of much value because they were improperly equipped with tools.

THE HONOR SOCIETIES

BY C. E. NOERENBERG

TAU BETA PI

The honorary engineering fraternity of Tau Beta Pi was founded at Lehigh University in June, 1885, for the purpose of securing for the students of technical and scientific schools the same recognition for high scholarship that Phi Beta Kappa gives to students in literary courses, whose attitude at that time was hostile toward engineering students. Prof. E. H. Williams, Jr., its founder, felt that the latter deserved a similar recognition for superlative work and an additional spur toward eminent success, as well as the advantages of association with men of like aims and qualities. He planned so well that the only engineering honorary fraternity has planted twenty-six chapters in the most worth-while engineering schools of the country and through its graduates is taking no small place of power and prominence in the active engineering profession. Its live organization publishes a quarterly magazine called *The Bent,* whose large circulation keeps the alumni and students in close touch.

Undergraduate students are eligible to consideration for membership, the "honor man" at the end of the sophomore year of each class being the first man eligible. Sixteen of the next highest students are selected at the end of the first semester of the junior year and eight at the end of the second semester. In no school is either group allowed to be in number more than one-eighth of the class. Scholarship forms the fundamental basis of election, though personality, promise of success, etc., are some of the other factors.

The objects are not only to emphasize superlative scholarship but to cultivate a desire for the "humanities" and a loyalty of service to one's alma mater and fellowmen, as well as to promote good fellowship and to make the technical graduate a well-rounded man. The activity of membership is undergraduate and the fraternity attempts to cultivate the social side. For this reason the local chapter has maintained a house for a number of years and a number of other chapters have followed its example. The undergraduate years are considered merely an introduction into the busy years of active practice in the engineering profession.

SIGMA XI

The honorary scientific society of Sigma Xi was founded at Cornell University in November, 1886, by Prof. Henry S. Williams, for the purpose of recognizing scholarly merit and research ability in students in scientific courses and of encouraging original investigation. It has established twenty-eight chapters in the more prominent universities of the country and has started the publication of a magazine containing largely items of news and notes on the progress of scientific investigations.

It is not an undergraduate organization though seniors are eligible toward the end of the year. The membership is composed largely of faculty members and graduate students who become eligible upon the publication of research work along scientific lines. Scholarship is recognized in selection though not exclusively, but the ability to conduct research is required. The candidates are nominated and elected by members in the faculty.

Meetings are held approximately monthly and are largely formal in character. Talks and discussions on research subjects are mingled with lectures by prominent scientists.

THE SAFETY FIRST MOVEMENT

ACCIDENT AND ACCIDENT PREVENTION IN THE MECHANICAL FIELD

During the football season, a headline reading,

FOOTBALL SPECIAL COLLIDES WITH FREIGHT. A——— HAS ARM BROKEN, SEVERAL OTHERS SERIOUSLY SHAKEN UP.

would command the attention of all Chicago, and receive comment from all over the country.

Contrast the prominence which such an article would take with the space and attention given to accidents in the laboring world. Without a doubt a much more truthful article could be written for almost every working day in the year, the headlines being not "One man temporarily hurt", but "Twenty men killed, one-hundred seriously injured, and eight-hundred temporarily disabled."

However, no such headline is going to appear. The papers are going to continue to portray the horrors of the football field and the class rush, and decry the railroads in their insane speed and lack of caution. The father and mother, at home, are going to remain steadfast in their attitude that their son shall not play deadly football or participate in class athletics, and all the while the ranks of our laboring forces are going to be riddled by unnecessary accidents, at a rate which rivals even Gettysburg.

We ask why the papers don't publish these conditions if they are so. The answer is that we would not buy the paper if they did. Even now you censure and condemn the *Chicago American*, saying that it prints nothing but horrors. To a large extent a paper will publish that which its readers want it to publish, and suppress the rest. By our attitude and our lack of support, we beat down any movement which tends to place the conditions of the working classes in a light where public opinion will demand that such conditions be changed.

The starting of a new movement may be just noticed now. Let us hope that it will be the dawn of a new industrial day, and that the new born "Safety First" movement will be the means whereby the death rate of "one man killed out of every one hundred working" (1911 Bureau of Labor Statistics) will be a thing of the past.

The start of the new movement seems to have been largely through the insurance companies, where an increasing number of

accidents meant an increasing number of claims to be settled. Some agitation was also started by a few of the manufacturing concerns and social organizations, the object being purely philanthropic. The Aetna Life Insurance Co. has published several bulletins under the name of "Safeguards", while the insurance interests in general are issuing magazines of a similar nature. The U. S. Government is now compiling data, which will become more valuable within a few years.

At the present time the most complete information is that compiled by the German Government, covering conditions in Germany since 1897. A report entitled "Accident Prevention and Relief" by Schwedtman and Emery, together with the U. S. Bureau of Labor Bulletins, Nos. 92 and 94, quote the results of the German investigation in considerable detail.

An effort was made to see if the conditions in this country checked with the German investigations, but the sources of information gave widely varying results, making it impossible to get any satisfactory comparison. The following table, compiled from the statistics of the German reports, shows the comparative hazard of the industries mentioned. Whether or not these conditions are true for this country cannot be told as yet.

Industry	Temporary Disability	Partial Permanent Disability	Permanent Disability	Total Occupational Accidents	Deaths
Agriculture	45	45	32.5	43.5	30.5
Iron & Steel	9	13	13	10.5	7.25
Structural	9	6	5	7.5	8.5
Mining	8.5	6	5.5	8.25	19.0
Railroads	3	4	18	4	8.5
Miscellaneous	25.5	26	26	26.25	26.25

The figures represent percentage of total injuries in the respective class, i. e. 45 per cent of the accidents causing temporary disability are due to the agricultural occupation.

The fact that in Germany the agricultural industries are so much more hazardous than others, is undoubtedly a point of considerable interest and surprise. In this country the general consensus of opinion seems to be that either the iron and steel or the railroads are the most hazardous.

Following is a summary of the American conditions, as given in the U. S. Bureau of Labor Bulletins for 1911.

One laborer out of every 100 working in shops, received injuries which caused permanent disability or death.

As compared with the previous years, the total accident rate is decreasing.

The number of accidents causing death is decreasing.

The number of accidents causing permanent or partial disability is decreasing.

The number of accidents causing temporary disability is increasing rapidly.

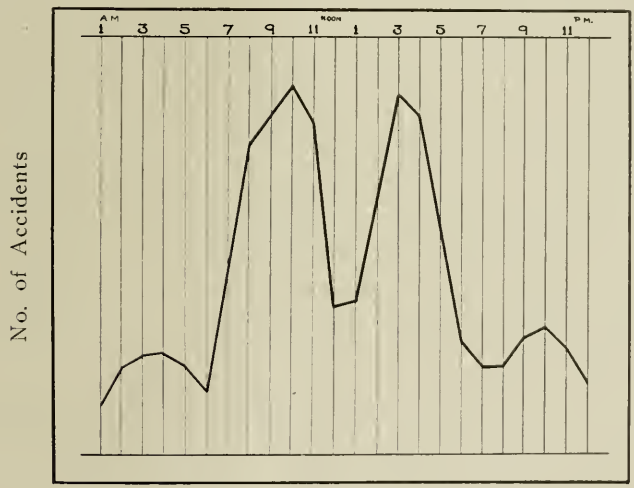
Accident rate for men is higher than for women.

Accident rate throughout the year is nearly constant.

Accident rate for Monday A. M. and Saturday P. M. is higher than for rest of week.

Accident rate for men employed less than one year, is much higher than for those employed for more than this time.

53 per cent of accidents consist of fractures or crushing of arm or leg.



Curve Showing Time of Occurrence of Shop Accidents.

The curve in the figure was plotted from the Minnesota Labor Bulletins for 1911, and is typical for the average American shop. It shows that the greatest number of accidents occur at about 10:00 A. M. and 3:00 P. M., with secondary peaks at 2:00 A. M. and 10:00 P. M. in the shops which work at night.

Following are some of the more common accidents and methods of prevention.

Fly wheel bursting. Due usually to the governor belt breaking, allowing the governor balls to drop, thereby allowing the engine to race. On the Corliss engine, when the governor comes to a maximum low position, a set of safety cams cut off the steam supply. Other devices shut off the steam when a predetermined speed is reached. On turbine alternators, a slight increase over a predetermined frequency, causes both electrical and steam ends to be cut off.

Circular saws. A steel finger is placed back of the saw to keep warped stock from pinching the saw and being thrown back. A cover over the crown of the saw protects the workman's hands. On band resaws and edgers, a set of fingers, placed back of the feed rolls, keeps the stock from being thrown back.

Joiners. The use of a cylindrical arbor in place of the square head arbor. In case of accident, only the tips of the fingers are cut, rather than cutting off the whole finger as before. A self adjusting guard protects that part of the knife not in use.

Band Saws. The lower wheel is encased in the base of machine or placed below the floor, the upper wheel is protected by a screen guard. In case the saw breaks or comes off the wheel, it will be held from striking persons working near the saw.

Emery Wheels. Tae Carborundum Co. and several other manufacturers are putting out a convexed or grooved wheel, held in place by a cupped washer, which tends to hold the pieces in case the wheel breaks.

Gears. The more modern types of machinery are built with gears covered, but in cases where they are not, a cover should be placed over them.

The principal means of reducing the accident rate in shops, is through education and coöperation of employees. A workman should never be permitted to operate a machine until he thoroughly understands its action. Some means should be provided to counteract the tendency to become careless as one becomes thoroughly acquainted with a machine. This is well done by means of safety signs and buttons, placed where they will serve to remind the workman of danger.

"Although there are parts of a machine which cannot be safeguarded by any known means, and though the employees engaged in operating machines know of these unguarded parts, some of them will nevertheless perform their labors in a way which borders on criminal negligence. To place a ladder on a

revolving shaft and mount thereon; to crawl under moving machinery; to reach across dangerous parts of a machine; to work in baggy sleeves or flying tresses of hair about dangerous gearing or shafting; to jump on or off elevators in motion; to adjust belts on rapidly revolving wheels; to carelessly hook up objects about to be lifted; to speed overhead cranes without warning are some of the negligences on the part of the employees. Until negligences like these shall have ceased, accidents, fatal and serious, will continue to occur, even though the employer of labor exert himself to the utmost to prevent them."

Constant warning and eternal vigilance is the price of safety.

O. C. K. HUTCHINSON, '16.

SAFETY FIRST IN ELECTRICAL APPLIANCES

The Safety First Movement in the electrical world has been a matter of slow but steady growth. It has been the result of experience and investigation by the practical men in the business who have applied the knowledge gained from their own investigations. For this reason, there is practically no literature on the subject. Safety devices hardly stand out as such but are regarded as matter-of-fact by the public. Only when one stops to discover the basic principles can the safety idea be seen. For these reasons no formal outline can be used in treating this subject, as there are no distinct divisions of the subject-matter. Perhaps the nearest approach to divisions would be the Safety First Movement as it affects the public, the workman, and the manufacturer, but even these are closely inter-related. Possibly the best way is to present the different items in the order of their probable interest.

Many devices used in everyday life in the home are in reality safety devices. Fuses, for example, protect the house from fire, acting in the same manner as a safety valve on an engine. Lightning arresters on power and lighting circuits, and on telephone systems are to protect the public. The rule of the Chicago Telephone Company, so bitterly condemned by the subscribers, which states that all desk-type telephones shall have their signal boxes placed at a distance away from a radiator or any other grounded object equal at least to the length of the cord and pedestal, is designed to protect the users from high voltage currents passing from the metal of the telephone, through their bodies, to the ground. The rules of the National Board of Fire Underwriters,

the bane of the inside wireman's existence, constitute probably the oldest of the Safety First literature, although they were seldom regarded as such. But without them, or an equivalent, the probable loss of life and property would be appalling. For the traveler, the many systems or block signals and safety devices are provided to make his trips safer.

The electrical trade, one of the most hazardous of the occupations, is now losing a few of its dangers since the start of the Safety First Movement. The lineman working on the "4600 hat" is now required by many companies to use rubber gloves and Matthews Lineman's Shields. The latter are sheets of rubber which are fastened to the wires or any current-carrying parts in the neighborhood of the workman. In most companies the gloves and shields are tested periodically at voltages in excess of those normally in use. The excess factor of the Commonwealth Edison Company is two and one-third. An old linemen's custom was to carry a small "ground chain" on all work, with which the wires were wound around once and then the end of the chain dropped to the ground. This caused a short and ground circuit if the "juice" was accidentally turned on. So effective is this simple device that most power companies require its use. In addition to this precaution, the switch controlling the circuit on which work is being done is tagged with a red "Danger" card. The switch is not to be closed without the permission of the foreman, who only gives this permission after the lineman has reported the circuit ready. Some switches are provided with locks having only one key. This absolutely prevents anyone but the foreman from closing the switch. In large cities like Chicago or New York, where all such work is ordered by the load dispatcher from his central office, the closing or opening of a switch without his permission is sufficient cause to warrant dismissal. Safety belts and buck-straps to check the lineman's fall if his spurs slip are really safety-first devices. The inside wireman, who handles low voltages (600 volts and less) does not need so many protections. His main device is rubber gloves and insulated tools when he handles 500-600 volts. The power house man and switch board attendant have a life almost as full of danger as the lineman. Oil switches, remote control through low voltage devices, and strict supervisory rules have lessened these hazards. In the newer stations, all control is effected by means of relays and low voltage motors, the operator only hand-

ling small levers or pushing buttons none of which operate at a voltage that is dangerous. In the older stations, all high-tension parts such as wires and busbars are surrounded by grounded wire screens. To touch any of them, the operator must stand on a stool which has high tension insulators for legs, place a rubber mat on this stool, and then use rubber gloves. Patent insulated forceps are used whenever possible. The slogan seems to be "Consider every piece as carrying current until you *know* otherwise; then use the same precautions as before." Some progressive stations have all current carrying parts painted certain colors to conform with their voltages, such as black 0-250; red, over 13,000. The New York Central Lines paint on all poles the voltage impressed on the lines upon them. The Commonwealth Edison Company used cards with "Danger,—Volts" printed in red on them. The Steel Mills at Gary, Indiana, have similar signs printed in several languages. On the powerhouse switchboards, all instruments are grounded, as are all railings, gratings, motor frames, etc. Knife type disconnecting switches are opened either by the means of long, dry, wood poles, or by a rope in which there is a section of fibre for insulation. Many other systems are used to protect the operators, but these are perhaps the most common.

The manufacturer who uses electricity for light and power must protect his workmen from the current, as they are usually ignorant of the usage of electricity. The men are always cautioned not to touch any metal in or around any electrical appliances and to leave all repair work for the electrician. Men running machines with motor drives have to start and stop the machine frequently. To protect them, the rheostat-regulator and the line switch are so enclosed that only their handles, which are made of non-conducting materials, protrude. This system makes injury by touching "live" parts impossible. High voltage and high amperage motors are handled by the means of low voltage remote control relays. Incandescent lamps are enclosed in cages to prevent breakage in a workman's face. Instruction about handling electrical appliances by means of bulletins aids in the work. So recent is the extensive use of electricity in manufacturing that there are few other methods of protection in use.

From these ideas it may be seen that the Safety First Movement in the electrical world is just starting. With the aid of the American Institute of Electrical Engineers, the National Electric

Light Association, and the National Board of Fire Underwriters, the improvements in the next few years will take electrical occupations out of the class of the "extra-hazardous" and put them on a common footing with the other trades.

R. V. WALLER, '16

SAFETY IN MINING

Mining is more dangerous than any single industry. Besides the danger peculiar to mining alone, there exist those characteristic of other industries. Accidents due to belting, gearing, electricity, etc., which occur largely on the surface are illustrative.

Accidents about mines may be divided into those occurring underground and those occurring on top. The latter have been enumerated above in a general way and as the methods for preventing their occurrence are pretty well known to the public in general they will not be discussed in this paper.

In order of their importance those which take place underground are due chiefly to (1) falls of roof or mineral, (2) electrical causes, as contact with trolley wires or machine cables, (3) crushing between cars, or between cars and sides of entry, and (4) explosions of coal dust or gas.

The fatalities due to falls of roof or mineral are greater than the fatalities from all other causes combined. The mine inspector of Pennsylvania in his 1913 report on the Bituminous field states that 2½ times as many men were killed by falls as were killed by crushing and one-fifth as many killed by electricity as were killed by crushing. The writer has no statistics concerning metal mine accidents, but is of the opinion that falls are largely responsible for the accidents. This opinion is based on a very limited experience in metal mining in southeastern Arizona.

In justice to the mine owner or operator it must be admitted that a large proportion of the accidents are due to carelessness on the part of the miner. He soon becomes accustomed to the novelty of facing death, as a result of which he becomes exceedingly careless.

Having analyzed the causes of accidents in mines we will take up the means adopted to prevent their occurrence. The Safety First Movement is comparatively new, but is being taken up enthusiastically by mining companies and already good results have been secured. In some states laws have been passed, the object being to increase the safety of the miner.

In coal mining the United States Coal and Coke Company of W. Va., subsidiary of the Steel Corporation, has been very active in its campaign for safety. The success with which they have met is due to the adoption of the following four practices.

1. The employment of assistant mine foremen, each having charge of 25 to 35 men.

2. Introduction of a premium system, which encourages foremen and their assistants to be on the alert for bad practice.

3. Systematic timbering.

4. Adherence to standard methods in laying track, bonding rails, hanging trolley wires, etc.

The company engineers have written a book of rules and regulations covering all operations, both underground and on the surface, and a copy is given to each mine foreman and his assistant. The latter are assigned certain districts underground and are expected to examine the places where men are to work for gas and dust, see that the roof is in good condition and to compel the men to work according to standard requirements which include such things as loading holes, firing shots, building brattices, in fact, all that pertains to their daily work. The assistant must check the men in and out of the mine also.

The premiums given to the "boss" and his "straw boss" induce them to fulfill their duties to the very best of their ability. The premium is outside of the regular wage and amounts to $5 to $10 a month, depending upon the number of accidents which occur in the district.

To lessen the accidents from falls of roof which, as noted earlier, cause the most deaths, systematic timbering must be resorted to. In the W. Virginia coal fields experience has shown that for roadways, posts set 3 feet on centers, with 6 foot caps at right angles to the track sustain the roof satisfactorily. In rooms props must not be placed at a greater distance than 6 feet from the coal. There is no doubt that in many places props twice that distance from the coal would provide ample safety, hence at first thought it may appear as though timber is wasted. However, it is better to have a margin on the side of safety. If the miner were allowed to use his judgment there is no doubt that he would not timber sufficiently, preferring to take a chance with his life for the sake of a gain in time which increases his tonnage, hence his daily earnings. Those who know the nature

of the miner marvel at the chances he will take to do just such a thing.

In many metal mines in the West timber is used very sparingly, the result being a high death rate from falls of rock. The only precaution the miner can take is that of "barring" down loose pieces immediately above his working place. However, as many stopes are 50 feet or more in height the impossibility of "barring" is obvious. In such a case the miner must take a chance. Quite frequently injury or death results. Where the rock must be supported by the square-set method of timbering, accidents from falls are less numerous. This method is not used unless conditions are very bad because of its great cost, hence often the miner is exposed to great risk.

The practice followed in the mines of the U. S. C. & Coal Co. can be applied to any coal mine, varying the details, of course, to suit local conditions.

The bulk of this discussion was given over to safety in coal mining because to us, in Illinois, it is most important. Many of the suggestions apply equally well to metal mining. Furthermore, outside of precautions taken on the surface in the machine shops, mills and power plants of metal mines, the Safety First Movement is making slow headway there, if one can judge correctly by the attention it is receiving in the technical press.

Results obtained in W. Virginia in the mines of the United States Coal & Coke Co., have been good, but a bit disappointing. In four years, fatalities have declined from one for each 100,000 tons to one for each 400,000 tons of coal extracted. During the first three months of 1913 there were no fatal accidents at any of the 12 mines operated by the company. The total production for this period was over a million tons of coal.

Though progress has not been rapid, in some cases even a bit disappointing, there is no doubt that a step in the right direction has been taken.

W. LERICHE, '14.

SAFETY FIRST IN RAILROADS

This great movement was started by Mr. R. C. Richards of the Chicago & Northwestern Railway in January, 1911, and since that time has spread to more than fifty railroads in the United States, controlling 200,000 miles of track, more than three-fourths of the total mileage in the United States. Universal interest is

being shown in this movement. From time to time Mr. Richards receives letters from people interested in safety on roads in foreign countries. It was after thirty years of careful study of accidents and their causes that the great crusade against carelessness was started. Railroads in 1911 paid on account of injuries to persons during that year, the sum of $25,979,747 or .946% of their gross earnings; and for loss and damage to property $33,978,746 or 1.238% making nearly $60,000,000 or 2.19% of their gross earnings. Most of this loss was due to carelessness of persons in little things, things that were thought to be of no great importance. The magnitude of the little things can be more clearly shown by the following statistics. In 1912 only 19% of the employees fatally injured on the Baltimore & Ohio Railroad were injured in train accidents, while the other 81% were due to the so called little accidents. The Interstate Commerce Commission report of 1912 shows that of the 10,185 persons killed and 77,175 injured on railroads in 1911-12, only 859 met death and 17,073 were injured in big accidents such as collisions, derailments, boiler explosions, etc. The little things for which most accidents are responsible are caused by such things as exposed nails, carelessness in coupling or braking cars, hopping cars, and throwing rubbish from car windows; all of which are done unthoughtfully. Still they help to swell the list of killed and injured each year. In 1911-12 over 900 persons were killed and 6,600 were injured from falling off cars and engines, 4,000 were struck by trains in switch yards, and out of this number 2,038 were killed. So the list continues. All these accidents are due to the things that most people consider of no great importance.

With the advent of the Safety First Movement which has made more careful and efficient employees, the percentage of killed and injured has been greatly decreased. The first twenty months of operation of Safety First on the Chicago and Northwestern Railway showed the following decreases below the corresponding previous twenty months:

	Killed		Injured	
	No	%	No	%
Employees	47	27.9	4471	31.4
Passengers	8	36.6	217	16
Other persons	97	24.3	157	15.4

The records of the Chicago, Burlington & Quincy Railroad

showed 35 to 45 injured each month by exposed nails, but after the safety first was started only about 15 were reported. The safety first campaign has been a great success, but there is no reason why it should not show a decrease of 50% or 60% instead of 30%, after the organizing is perfected.

The success of the movement was assured when the employees were made to realize their own responsibility, and to what extent their own safety was involved. In order to reach all the men concerned, Mr. Richards would talk to the men in small groups in shops, roundhouses, or in large gatherings. This was only necessary while the safety first plan was in its infancy. On each of the seventeen divisions of the Northwestern line committees have been organized whose duty it is to take up all subjects concerning safety that may come up. These committees meet once a month for an all day session at which papers are read and all matters that tend to make travel safer are discussed. Each employee of the road is encouraged to make suggestions and submit them to these committees. In addition to these separate committees there is a central committee which takes up things that concern the whole system. The first year that this system was in force, 5,000 subjects were discussed and acted upon, and in the first two years, 200 changes were suggested and made that affected the whole system. Practically the same system, as employed by the Northwestern line, is in effect upon other railroads that are advocating this movement. About a year ago a great safety meeting was held in Kansas City at which fourteen roads were represented by 500 officials and 9,000 employees with their wives and children. This was an all day meeting and many interesting talks were made. The main speaker of the day was Mr. Richards, the pioneer of the safety first movement.

There are many ways in which the danger of carelessness is impressed upon those concerned. When an employee receives his pay check, a sticker is attached to it with a reminder such as: "It is better to be careful than to be crippled," or "Boost for safety first," "not safety second, or safety last, but always and everywhere safety first." There are many similar notices posted around shops, roundhouses, stations or any place where passengers as well as employees will see them. These are not given as commands from the officials of the company, but just as golden rule hints from the boys that are on the committees and are studying these matters. The great railroads of the country are show-

ing their interest in safety by sending safety first cars over their systems and lecturing and showing pictures to audiences, and pointing out the danger of carelessness. In addition many roads are offering rewards for safety devices that will help to make travel safer. The automatic stop devices are good examples of improvements of this kind. There are two kinds of automatic stop devices that work in connection with the block signal systems; one invented by Fredrick LaCroix and another used by the Pennsylvania Railroad on a five mile track just out of Pittsburgh. There are other safety devices used, such as automatic couplers, block signal systems, guarded foot and hand holts, and all-steel coaches.

The safety first system has decreased the number of killed and injured, and at the same time has increased the profits of the company. This is a very desirable state of affairs as far as the stock holder is concerned and of course everything within reason is being done to bring about better conditions. The railroads are doing all in their power to make more efficient workmen and safer means of travel, but passengers must be careful also, if the best results are to be obtained.

JAMES A. WILSON, '14.

The time is at hand, however, when the engineer should be so educated as to appreciate the artistic possibilities in his product, and to exhibit an aesthetic sense in design. When the great engineering feats of today become the ordinary products of tomorrow, the public will demand beauty of design, as well as rigidity and utility of construction and installation.

A. C. SCOTT.

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EDITORIAL

TIME AND PLACE SCHEDULES FOR STUDY

Among the bits of fatherly advice passed out to a freshman shortly after entering college one will remember the statement given with such axiomatic certainty of its wisdom "A place and time for everything, and everything in its time and place." The conscientious efforts made to obey the commands of this rule and the anxiety caused by a failure to observe its dictates to which were attributed poor recitations and flunks will also be recollected. Possibly the determination to abide by a time-and-place schedule slackened before the end of our first semester and perhaps before the year closed to do so was even looked upon as futile. This

was the attitude finally taken by some men, who then may have disregarded the rule entirely with the result that their study tables became typical "student tables" upon which were heaped in grand profusion everything from tablets to tennis rackets.

There were, however, others who analyzed the rule and found that it consisted of two distinct parts, a place schedule and a time schedule. With this idea in mind they decided to give it a new trial and see wherein the fault lay. A place was found for everything, books were kept in the rack, ink at one corner of the table, tablets at the other, pens and pencils in the table drawer, notes and problems were carefully filed, etc. Considerable efficiency was acquired because the time lost in looking for an object was reduced to a minimum. The first part of the rule proved helpful.

On the other hand, the attempt to follow the time schedule was still futile and it was eventually abandoned. A search for the causes that made it impractical and ineffective showed the following facts:

College life is not "the simple life." There are many attractions to claim our attention. We must continually work under pressure to be able to crowd in the different lectures, shows, and athletic contests. These all break into a time-schedule in which provision cannot be made for diversions, as these are not announced far enough in advance to allow us to make an adjustment in the schedule. Their very irregularity must necessarily disarrange any system. Secondly, assignments in the same subject are not equally easy or difficult day after day. A mathematics lesson may require a half-hour preparation one day and the solution of a number of problems may consume the greater part of an evening the next day. One subject will and should encroach upon the time limits of the other in proportion to the preparation demanded at the time. The third, and perhaps the most important reason why the time schedule is ineffective, is the attitude of mind created by the idea that one thing must be done at such a time and another thing at another time, in place of doing immediately that which the material and conditions at hand will allow. A secret of success in study as well as in other activities consists in doing *now* that which has to be done. Another factor that enters into success lies in the ability to weigh judiciously the relative importance of two conflicting engagements. This faculty of judgment is not developed by adhering

to a pre-determined schedule which cannot be violated. Only when the will is given free play to select the immediate occupation and to decide upon the course of action can that which is necessary be separated from the unnecessary. By doing immediately that which requires most attention, the entire course of the day is completely filled in and study will receive the consideration due it.

PROMINENT ENGINEERS ON SPECIALIZATION

The engineer must be a man of broad view. He has large things to do in every part of his work, large undertakings to be carried out, large investments of capital to be properly expended; and no small man can do these large things well. For this reason I think his training at school should not be narrowed down to a specialty but that he should have a broad culture, one that will tend to help him in these lines and to make him fit to do what he must do in life if he is to succeed.

M. J. RIGGS, C. E.

It is in lack of a broad appreciation of the real meaning of success that the engineer makes his greatest mistake, leading to the narrow type of our early characterization. Whatever broadens the whole man must necessarily fit him for his special work.

FRANK H. CONSTANT.

Education is not the learning of a trade or a profession, but the development of the intellect and broadening of the mind afforded by a general knowledge of all the subjects of interest to the human race. . . . .

It must be realized, however, that the value of the specialist in the social organism is in direct proportion to the general knowledge which he possesses.

CHARLES P. STEINMETZ.

SUCCESSFUL MEN ON SUCCESS

Do not make the very common mistake of measuring success by the amount of money you can earn. One must have money and enough to live on, but it is not the all important thing at the beginning of life. It becomes really important only when one's working days are drawing to a close.

DR. M. E. COOLEY.

An engineer's success in life depends greatly upon two things: First, the thoroughness with which he has pursued his studies at his technical school; and, second, the start that he makes immediately after leaving there.

J. A. L. WADDELL.

I look upon that man as happy, who, when there is a question of success, looks into his own work for a reply; not into the market, not into opinion, not into patronage. Work is victory. You want but one verdict, if you have your own you are sure of the rest.

RALPH WALDO EMERSON.

Success is not measured by what a man accomplishes, but by the opposition he has encountered and the courage with which he maintained the struggle against overwhelming odds.

ROBERT BURNS.

You will find as you go through life that earnestness of purpose is the mainspring of success, and that if you set your mind on attaining any object within, you will, if you keep on trying, eventually succeed in attaining it.

J. A. L. WADDELL.

The question for each man to settle is not what he would do if he had the means, time, influence and educational advantages; the question is what will he do with the things he has. The moment a young man ceases to dream or to bemoan his lack of opportunities and resolutely looks his conditions in the face, and resolves to chance them, he lays the corner-stone of a solid and honorable success.

HAMILTON WRIGHT MABIE.

DEPARTMENT NOTES

E. E. SOCIETY

The first joint meeting of the A. I. E. E. and the E. E. society was held Jan. 10, 1914. Mr. Belt, a graduate student in E.E., reviewed an article on The Use of Electricity in Gas Motor Cars, written by Waller. Following this there was a general discussion in which many of the students showed how well they had used their summer vacations.

In the next meeting, held Jan. 22, the first semester's work was wound up. The treasurer's report showed a balance in the treasury of $139.10. A hotly contested election of officers for the second semester followed. The final result was: President, H. R. Tear; Vice-president, E. A. Williford; Secretary, R. V. Waller, and Treasurer, H. H. Henline.

Due to various causes there has been but one meeting the second semester. It was held Feb. 14 at 11 A. M. in the E. E. lecture room. Mr. F. H. Millener was the speaker and gave a very interesting though non-technical discussion. His subject was "Light Waves—Visible and Invisible". He is experimental engineer for the Union Pacific railroad and most of his discussion dealt with experiments on wireless communication with moving trains which this road is carrying on.

The E. E. faculty has been again increased by the addition of Mr. C. R. Moore. Mr. Moore was graduated from Purdue University in 1907 and since them has been engaged both in commercial work and as instructor. He received his E. E. degree in 1910 and is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi fraternities.

Many E. E.'s have been reminded of the last E. E. show by the loud snapping as the 200,000 volt transformer causes a rupture to occur between the large brass balls. The transformer has been well caged in and two postgraduate students, Wolf and Mathews, are now running a series of tests on it.

E. A. James, '15.

C. E. SOCIETY

Owing to the lectures of the short course in Highway Engineering the C. E. Club did not have its usual number of talks during the last three months but devoted most of the time to club business and to the election of new officers.

At one of the meetings Mr. N. B. Garver, Associate in Civil Engineering, gave a very interesting illustrated lecture on Concrete Highway Bridge Construction. At another meeting Mr. J. J. Woltmann gave an interesting talk on The New Sewerage System at Anna, Illinois.

The officers elected for the present semester are: F. T. Sheets, President; W. H. Boyer, Vice-president; F. W. Panhorst, Secretary; R. F. Reilly, Treasurer. The new officers took their respective posts at the meeting on Feb. 20.

J. E. DEMUTH, '15.

M. E. SOCIETY

At a special meeting of the A. S. M. E. society held on February 17, the following officers were elected for the coming semester: C. R. Velzy, President; J. A. Wilson, Vice-president; J. L. Alden, Treasurer; and E. F. Gehrig, Secretary.

At a former meeting Professor Moore of the T. & A. M. Department gave an illustrated talk on "The Fatigue of Metals." Professor Moore disproved by actual experiment, during the course of his talk, the old theory regarding fatigue of metals, namely that the material cracked around the crystals, by repeatedly stressing a piece of wrought iron beyond its elastic limit while watching its action on the crystals through a microscope. Cracks were soon visible across the face of the crystals.

H. E. AUSTIN, '15.

MINING DEPARTMENT

While the "Soldiers" were tripping merrily at the Military Ball on Feb. 20, the "Miners" were pulling away on old stogies at one of the most successful smokers that they ever attempted. An unusually large number of new men registered in mining this semester and they were welcomed into their new profession at this gathering by the older members. There was the usual abundance of eats, drinks, and smokes that marks the mining smokers. The most interesting part of the program was the speeches which were very cosmopolitan in their nature, three continents being represented.

The situation of the copper strike in the upper peninsula of Michigan was very ably discussed by Professor Young, former Director of the Missouri School of Mines. Professor Young is

making labor troubles a special study and thus he was able to bring out many points that one would not get by following the daily papers.

A talk which, though non-technical, was very interesting was given by Thos. Hall about mining and living conditions on the Rand, South Africa. Mr. Hall worked in the chemical department of one of the large gold mining companies there and his duties took him into all parts of the underground workings. He also described the customs of the natives which are very peculiar.

Mr. S. O. Andros of the Illinois Coal Mining Investigations described coal mining conditions in Europe. Mr. Andros spent some time in England and France making a study of foreign methods of mining. For this reason he was able to point out marked differences between European and American methods of mining coal.

The duties of a mine surveyor were outlined by Mr. H. E. Willson who was with the engineering corps of the McKell Coal Company at McKell, West Virginia, for several years.

At a meeting of the Mining Society on Jan. 27, the following officers were elected for the second semester: President, L. R. Bell; First Vice-president, W. Leriche; Second Vice-president, J. G. Roberts; Secretary, H. L. Stafford; Treasurer, J. E. MacDonald.

Bradley Stoughton, secretary of the American Institute of Mining Engineers, visited the Mining Department on Feb. 25. It had been the intention of the student branch of that organization to tender him a banquet but owing to the ban of the Council of Administration on University activities during the scarlet fever scare it was not held. All arrangements had been made and it was a disappointment to all interested in mining that it was prevented.

At the next meeting of the mining society Mr. R. Y. Williams will give a lecture upon the coal fields of Alaska which will be illustrated by a number of slides. These slides which were prepared from photographs taken by Mr. Williams while in Alaska will then be shown here for the first time publicly.

S. T. WALLAGE, '15.

THE RAILWAY CLUB

On January 9 the Club had the pleasure of listening to Mr. Featherstone's talk on South American railways. Aside from

the individuality of each road, the country which it traverses, the peculiarities of the towns and villages which are along the road, the characteristics of the passengers, which were given by the speaker, the chaotic conditions of the railroads in South America were emphasized. One thing, judging from the information given by Mr. Featherstone, is certain, that a Harriman is greatly needed to combine and standardize the numerous small lines into a uniform system, and to establish through routes from one little republic to another.

Professor M. H. Robinson gave his talk on January 22. The topic was "Physical Valuation of Railroads." As is always the case when Professor Robinson speaks, a large attentive audience was on hand. Little need be said about the speech here, since the paper will be published in the next issue of THE TECHNOGRAPH.

This being the last meeting of the semester the new officers were elected as follows: J. A. Wilson, '14, President; C. J. Anderson, '15, Vice-president; S. V. Winquist, '14, Treasurer; H. E. Smith, '17, Secretary.

All signals reading "clear", the new administration passed into the second block without loss of speed. The first meeting of the second semester was held on February 20. Mr. G. E. Jacquet, '08, gave an interesting talk upon "Some Experiences with an Eastern Railway". The gigantic task of the electrification of the New York Central Terminal in the heart of New York City, the elaborate plans, the large organization and the methods of testing the apparatus used was explained in detail by the speaker. The Club was especially interested in Mr. Jacquet's personal experiences as they are what the graduate may expect to meet in his early career.

Nothing new in the School of Railway Engineering and Administration for the second semester. The popularity of this school is spreading. One more foreign student and a few new ones from other universities have registered in the course of Railway Administration and it will not be very long when more sections will have to be added. MAX RUKIN, '15.

SIGMA TAU

On Saturday evening, Feb. 27, a local chapter of Sigma Tau, a national engineering fraternity, was formally installed. Mr.

F. A. Wirt of the State Agricultural College of Manhattan, Kansas, was sent here by the fraternity to install the chapter. Co-operating with him were, Dean Richards, Prof. A. B. McDaniels, and Walter Wohlenberg of the Experiment Station and a member of the organization's supreme council.

Sigma Tau was founded at the University of Nebraska in 1904. Including the Illinois chapter, the fraternity now has seven active chapters. Its membership is restricted to juniors and seniors in the College of Engineering who are elected on the strength of their qualifications as promising engineers as shown partly by scholarship and partly by accomplishments and interest in engineering work.

The charter members are J. W. Bass, J. C. Butler, F. H. Bulot, A. Gonsior, J. M. Fetherston, A. Elmendorf, L. A. Liggett, J. E. McDonald, H. E. Pengilly, J. C. Phelps, E. S. Scott, C. H. Westcott, N. K. Wilson.

I would counsel the young engineer, fixing his ideal at nothing less than the fullest development of the whole man, to let a love for knowledge—for truth as seen from many sides—spring up and grow alongside of his enthusiasm for engineering. Especially should he seek the so-called humanities, which teach of man's relation to man, for here he will find the mainspring of human action. Students of engineering should not avoid but welcome occasional subjects from this group.

FRANK H. CONSTANT.

The whole of your life must be spent in your own company and only the educated man is good company to himself.

DAVID STARR JORDAN.

Absence of occupation is not rest,
A mind quite vacant is a mind distressed.

COOPER.

GLEANINGS FROM THE EXAMINER'S DESK

BRILLIANT DEFINITIONS AND OTHERWISE

An injector is used to create a draft in an engine flue, to draw water into a boiler, and sometimes to blow steam into a condenser.

Head end is the end of the cylinder towards the head end of the engine. In a sketch of a boiler or engine the head end is usually towards the left. It is the one which is opposite the back end.

Mechanical equivalent of heat is the amount of work necessary to convert a pound of water into a B. t. u.

The lead is the position of the D— valve.

Anything which helps increase the economy of a plant is an economizer. For example, an ash sifter.

The feed water heater is used to prevent boiler condensation.

The lap is the amount the port moves after it is opened before it is closed.

The heat of the liquid is the heat necessary to raise the temperature of a pound of water from the freezing point to 32° F.

Factor of evaporation is the unit of heat required to evaporate one pound of water into steam at 32°.

A syphon is a very simple device and is used very much to water flower gardens.

—273 is absolute zero because you can heat a body that cold and no colder.

Governing lessens the supply the higher the speed. Thus the engine is prevented from running away from itself and causing a mash-up.

A pop safety valve is put usually at the top of the boiler to regulate the amount of exhaust steam escaping from the boiler. The pop safety valve will give warning when necessary.

Illini Club of Chicago

Fifth Annual Easter Festival

Monday Evening, April 13th, 1914

HOTEL LA SALLE

Main Ball Room and Red Room

Promptly at 8:15

U. of I. Military Band — Dancing

Tickets at One and One-Half Dollars each may be obtained at the Illini Club of Chicago

Address 314 Federal St.

The Technograph

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IRA OSBORN BAKER
COMMEMORATING FORTY YEARS OF ACTIVE
CONTINUOUS SERVICE ON
THE FACULTY OF THE UNIVERSITY OF ILLINOIS

The Technograph

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THE PHYSICAL VALUATION OF RAILWAYS

BY MAURICE H. ROBINSON, PH.D.

Professor of Industry and Transportation

The enactment of a law by the Congress of the United States providing for a physical valuation of railways in the United States has given the subject more than an academic interest. In view of this fact, it is desirable that the subject should be fully discussed in order that the most economical and most efficient methods of valuation be adopted by the Interstate Commerce Commission.

It is evident that a valuation of any individual railroad, or the railroads of any given state, or the railroads of the entire United States, may be undertaken for any one of a number of different purposes, and that the purpose for which the valuation is made will have an important effect upon the scope and character of the work necessary to secure the valuation. The chief purposes may be classified as follows:

1. To acertain whether the railroad or railroads are solvent.
2. To ascertain whether over-capitalization has been practiced in the past and to prevent over-capitalization in the future.
3. For adjusting the burden of taxation.
4. To serve as a basis for purchase in case the public ownership of railroads has been determined upon.
5. To enable rate-making authorties to properly determine whether rates are fair as between railroads and the shippers and whether they are adequate for the proper maintenance of the railroad service.

It is also evident that while the purpose to be attained will have an important effect upon the method of valuation, there are several methods, fundamentally different, which may be used either independently or concurrently with the others for the purpose of ascertaining the value of the property sought.

The first method may be denominated the accounting method, the second the stock exchange method, the third the cost of pro-

duction or the cost of reproduction new, or the cost of duplication.

The accounting method is perhaps most direct of all. If the books of a railroad company are properly kept from the beginning, if the items of expenditure have properly been segregated so that all items properly chargeable to capital have been entered on the capital account and all items properly chargeable to expense have been entered on the expense account, and if proper allowance has been made for depreciation, then the balance sheet of any railroad will show its exact value at any given date. The difficulty encountered when public authorities or the directors of a railroad attempt to use this method are so numerous that it is not often available. Generally the items of expenditure have not been properly distributed. Consequently it would be necessary to go over the entire history of the railroad and to make a redistribution of all expenditures before any reliance could be placed upon the valuation as given in the accounts. Furthermore, the records have in many cases been destroyed, so that it is often absolutely impossible to use this method at all.

The stock exchange method is the simplest and easiest of all, but it is on the whole the least valuable. It is not proper within the limits of this paper to discuss the idiosyncrasies of the stock exchange. It is evident, of course, to any one who follows the market that the intrinsic values of railroad properties are not changing as rapidly as the market value of the stock. Where this method is used, it is always necessary to cover a considerable period of time; but during this period of time the physical condition of the particular railroad has been changing and a correction for such changes would have to be made before the average value could be taken. Moreover, the stock exchange method gives the value of stock and must be corrected for bonds and other obligations. But these are not the vital objections to the stock exchange method of valuation for purposes of public supervision. The value of a railroad's securities is determined by the profits and the profits are determined by the rates; consequently, while the stock exchange method may be available for purposes of taxation or of ascertaining its solvency, it is not a proper basis for establishing a system of rates.

The third method of valuation, that of ascertaining the cost of production or the cost of duplication, is, it will be noticed, the only one of the three methods which requires a physical valuation. A railroad occupies a considerable amount of land, including terminal sites and right of way through the country districts. The right of way is made up of a graded bed for the track and

usually requires a considerable amount of cutting and filling. On this road-bed is placed a track. The terminal site is covered with yards and buildings of various kinds. In addition to the land and the buildings, a railroad possesses an equipment made up chiefly of engines and rolling stock, freight and passenger cars. In addition, of course, it usually carries a considerable amount of supplies on hand, is provided with a reasonable amount of working capital, and in some cases has outside investments made up of stocks and bonds in other enterprises. In order to obtain a valuation of a railroad on the basis of cost, it is necessary first of all to make a complete inventory of the railroad's property, specifying by classes and by items under each class each individual piece, and after this inventory has been made, to place a value upon each item based upon its original cost less a proper amount for depreciation. Or a valuation from the physical standpoint may be obtained by an estimate of what it would cost to buy all of the necessary land, grade and lay the track, erect all of the buildings, construct all of the equipment and provide all of the working capital which the railroad possesses. It is evident, of course, that the results of these two processes would not be identical. The cost of a right of way purchased fifty years ago is very different from the cost of the same right of way purchased at the present time. On the other hand, on account of the increase in price, the cost of erecting certain buildings or providing certain parts of the equipment would be very much greater at the present time than it was when such buildings and equipment were provided. Moreover, the buildings and the equipment of any railroad are not all new. A portion of the equipment is nearly worn out, some of the buildings are old, and it is probable that in many cases such buildings must be torn down in the immediate future and more commodious ones erected in their place. It is not an easy matter to determine upon the exact amount of depreciation to allow. Depreciation may be due to any one of several causes. We are inclined to think of wear and tear of buildings and equipment as the principal causes of depreciation. This is only one of the various causes. In certain cases the depreciation due to the ravages of natural forces are even more important than use, and again there is an important factor that has not yet been taken account of—namely, the depreciation due to obsolescence. It is probable that the case last mentioned is less important in the ordinary steam railroad than in many other lines of work. The old engines that are out of date for the main line are used upon the branch lines. The same is true of the equipment. But, not-

withstanding all of the efforts that are made to wear out all of the varieties of a railway's equipment, there is a considerable portion that must be thrown away while still in a fairly good condition. The physical value of the railway, then, will depend upon not only the method of valuing land and the materials, but will also vary radically according to the scale of depreciation which is adopted. As a result of the adoption of various methods of valuation of the actual physical property and of a rate of depreciation, two different values will result, indeed must result, for any given railroad property. If the present value of the land is used and the rate of depreciation adopted is moderate, the valuation of the property will be high. If the original cost of the land and the equipment purchased fifteen or twenty years ago is taken, and the rate of depreciation adopted is high, then the valuation found by the authorities will be low. If the valuation is to be used to determine the solvency of a railroad, it is possible that a really solvent road might be declared insolvent if the method giving the lower valuation should be adopted. On the other hand, if the method giving the higher valuation were to be adopted, such valuation would justify high rates. It is, of course, not necessary to observe that the valuation which is proper for making rates is also the one that is proper for establishing the solvency of the railroad, or for purposes of assessing taxation. There is no reason why a railroad should be assessed upon a high valuation and forced to carry passengers at rates based upon a low valuation. The problem for all public authorities is that of ascertaining a proper and reasonable valuation of the property that should be the common basis of solvency, of taxation and of rates.

It is perhaps necessary at this point to call attention to the attitude of the courts towards the basis of valuation, since the results of the valuation adopted by any public commission are subject in the final analysis to the jurisdiction of the courts. Briefly, the courts have held, first, that the cost of reproduction is not controlling (212 United States, 1); second, that a company is entitled to a valuation based upon the present standard of prices—that is, if the property has increased in valuation since it was purchased by the railroad company, the railroad company is entitled to have the benefit of such increase, (212 United States, 19); third, that a railroad company is not entitled to a valuation based upon mistakes in judgment either in purchasing or construction (192 United States, 201).

The present project for a valuation of railroads of the United States is not a new one. As early as 1887 a fairly extensive

inquiry was made into the value of the Pacific railroads by a commission of the United States Senate. Since that time eleven of the states—namely, California, Kansas, Minnesota, Nebraska, Oklahoma, South Dakota, Washington, Texas, Michigan, and New Jersey—have undertaken more or less complete valuations of the railroads within their respective jurisdictions. Of these states, Texas was the pioneer, making a general valuation of the railroads within its boundaries in the year 1893. Probably the most extensive and most important valuation was made by Michigan in 1900. In this case the property was first physically valued by the inventory method and afterwards an added value was given, based upon the estimated value of the franchises. The experience of Nebraska is of considerable interest. In this case an estimate was made of the cost of grading, cost of clearing and grubbing, based upon contractors' bids; cost of rails, ties, etc., based upon prices that prevailed at the period for which the valuation was made. A complete inspection of all bridges, culverts, etc., etc., buildings, coal chutes, water tanks, etc., was made and an individual value assigned to each item. The land was separated into country real estate and terminals. In order to obtain the value of the real estate in the rural districts, 3,000 actual transfers of land lying along the right of way were consulted and 5,000 other transfers in the locality were taken into consideration. In order to get as scientific a valuation as possible, a unit value was devised and adopted, and this unit value was applied to each particular piece of land and the value of the land given on the basis of its relation to the unit value. A special investigation of the land values in the cities was made through experts in the various towns in which the terminals were situated. The result of the Nebraska valuation was, of course, fairly satisfactory and should to a certain extent serve as a guide to the Interstate Commerce Commission in its valuation of railroads for the United States.

The Minnesota valuation is of interest chiefly because of the cooperation between the railroads and the public authorities. The plan in this case was to determine first the cost of reproduction new, including both the real estate, the buildings and the equipment; and second, to deduct from the cost of reproduction new a proper depreciation for the time and the use to which the various items had been put. In the case of land, it was decided to find what the present cost of acquiring the same land would be if it were necessary to purchase from the farmers in the region through which the railroad passed, but not to allow anything on account of the fact that the farmers might be able to

obtain more than the farm value of the lands for railroad purposes. Very careful inquiry was made through record of transfers, the Commission actually examining more than 55,000 transfers of land, the sale price of which amounted to more than $100,000,000. In addition to the value of the land for farm purposes, an added amount was given on account of the damage of the railroad to adjoining land for cutting up parcels and other damages to the value of land which a railroad inevitably brings. On this basis it was found that in the country the valuation finally placed upon the railroad right of way was about three times the value of the farming land in the vicinity. For the purpose of bringing the results of the investigation together, a large office force was employed under the direction of a competent manager. Here units of cost for various kinds of work were adopted, and these units were applied to the physical inventory that had been made and a complete valuation thus obtained. It may be interesting to notice that the railroads were allowed for the interest upon their investment during the process of construction; that a reasonable amount was allowed for the general superintendency of constructing the railroad outside of the charges that inevitably are made in connection with contract work.

The valuations conducted by the various other states have perhaps added nothing new in the way of methods or principles of valuation to what has been contributed by the states of Michigan, Nebraska and Minnesota. The valuations in these cases were, however, for that portion of the various railroads lying within their own boundaries. We have one example of a single railroad lying in seven states which has been valued by a public authority, and in this valuation the railroad itself cooperated. That is the New York, New Haven and Hartford Railroad. The circumstances out of which this valuation grew are somewhat peculiar. In 1909 the Attorney General of Massachusetts in his annual report called attention to the relations of the New York, New Haven and Hartford Railroad and the Commonwealth of Massachusetts and gave it as his opinion that the company named had violated the laws of Massachusetts and had forfeited its charter and franchise. As a result of this opinion, a joint committee was appointed for the purpose of investigating the conditions and reporting to the General Assembly. The joint committee reported that, while it was clear that the laws of Massachusetts had been technically violated, the acts of the company had been acquiesced in by the public officials for so many years that it would be a public calamity to have the charter and franchise

forfeited; therefore advised that the New York, New Haven and Hartford Railroad Company petition the legislature of Massachusetts to examine its assets and liabilities and to determine whether or not it had exceeded its powers in issuing stock and bonds to such an extent that it was insolvent, and if it should be found that it had violated its laws or to be insolvent, it suggested that the legislature might validate the outstanding securities and thus by specific act make it unnecessary to take action in regard to the forfeiture of its charter. As a result of this recommendation a commission was created to make a valuation of the corporate assets of the railroad line within several states. In this case the railroad posessed two classes of property—first, the railroad property as generally understood; and, in the second place, securities, leases, and contracts. For the first a physical inventory and valuation was undertaken under the general direction of Professor George F. Swain of Harvard University. For the valuation of the second class of properties, the firm of Stone and Webster was employed. The board itself also made a considerable investigation, and as a result of these various lines of investigation prepared and published a complete report showing the value of the entire property of the railroad, including the securities as well as the physical property.

Attention has already been called to the valuation of the Pacific railroads by a commission of the United States Senate in 1887. The first general attempt to value the railroads of the United States was undertaken in connection with the census of 1900. This valuation, however, was not a physical valuation in any sense of the word. It was based upon railroad assessments in the various states and the market value of the stocks as shown on the various stock exchanges, and such supplementary sources of information as could be found without making an elaborate and complete investigation. Since the valuation of 1904 was published, various attempts have been made in Congress to secure the enactment of legislation for the purpose of securing a complete physical valuation of all the railroads. Nothing of importance came out of this agitation until 1913, when the Adamson Bill was presented to the House and passed by a large majority. The Adamson Bill was radically amended while before the Senate and was known on its passage as the La Follette-Adamson Bill. The act as finally passed provided that the Interstate Commerce Commission should investigate, ascertain and report on the value of all the property used by every common carrier subject to the provisions of the Interstate Commerce Act; that the Commission should have the authority to employ such experts

and other assistants as might be necessary; that it would have the power to summon witnesses and to take testimony, and that it should make an inventory of all the property of every common carrier and classify the physical property in accordance with the general classification of expenditures as used by the Commerce Commission. In making this investigation the Commission was required to ascertain and report in detail as to each piece of property owned or used by the common carriers and to report upon the original cost to date, the cost of reproduction new, the cost of reproduction less depreciation, and to prepare and publish an analysis of the methods by which these several costs were obtained, and the reasons for the differences if any should occur. The Commission was required in addition to report separately the original cost of all lands, rights of way and terminals used for the purposes of a common carrier, and ascertain as of the time of dedication to public use the value and the present value of the same. It also required to ascertain and report as to the amount of property that had been given by individuals and public authorities to the railroads for the purpose of aiding in establishment of the same. The Commission was given power to prescribe method of procedure, the form of submission of results, classification of elements of value, and was required to show in its final report the value of property as a whole and the value of property in each of the several states. After the completion of the valuation, the Commission was required to keep the same up to date so that for the United States there would be a perpetual inventory, as it were, of all the property devoted to the work of transportation by common carriers. The Interstate Commerce Commission in pursuance of the authority granted by this act has already appointed a board of engineers, has divided the United States into a number of districts, and has commenced the valuation, beginning on the San Pedro, Los Angeles and Salt Lake Railroad, extending from San Pedro, California, to Salt Lake City. This road was taken because it was thought the problems involved in its valuation were simpler than those generally prevailing, and that as a result of experience in this particular instance the work of valuation in other districts might be carried on more efficiently and economically.

The expense of a physical valuation of all the railroads in the United States will depend, of course, upon the completeness of the investigation and the care with which the valuations are made. The director of the division of valuation of the Interstate Commerce Commission, the Honorable Charles A. Prouty, estimates that the expense will be at least $6,000,000, and is more

likely to run up to $12,000,000 or $15,000,000. It may be asked at this point, Is it worth while to undertake this vast project? To this question no specific answer can be given. The valuation will be of interest as showing the amount of investment in the railways and will, of course, be a criterion of equity in taxation as between the railroads and the other industries. It will also be of value as showing the investors in railway stocks and bonds to what extent their securities are protected by actual assets, and it is probable that the valuation will be used more and more as a basis of just and proper rates. At the present time the railways in the northeastern portion of the United States—the region north of Mason and Dixon's line and east of the Chicago-St. Louis territory—are petitioning the Interstate Commerce Commission for a general increase in rates of five per cent. Their justification for this petition is that the present rates are not yielding a sufficient return upon the investment to attract investors to invest further in railroad securities. It is evident, of course, that unless we have a better basis of valuation of railway properties than exists at the present time that the contention of the railroads in this particular instance can neither be proved nor disproved. A physical valuation of the railroads, if it is carefully and properly undertaken and carried out, will enable the railroad commission to determine at once whether or not the railroads' contention is justified by existing conditions. It is thought by those who are in closest touch with the railways that a physical valuation will show not only that the capital stock and bonds are amply secured, but that on the whole the rates of transportation are in most cases so reasonable that no general complaint against the rate situation can be properly made. If the ideas of these men should as a result of the physical valuation prove true, it is evident that most of the complaints made against the railroads would be shown to have no foundation in fact and that the relationship between the railways, the public authorities and the traveling public would be much pleasanter and more agreeable than under present circumstances. The railroads are a part of our modern industrial system. It is necessary that they be allowed to charge rates sufficiently high to provide a reasonable return upon the capital invested. Under present conditions the railway commissions in the various states and the Interstate Commerce Commission are required to see that adequate services are rendered at reasonable rates. A physical valuation of the railroads would be of the largest possible value in determining when rates are too low as well as when rates are too high.

THE RELATION OF CERTAIN INDUSTRIES TO DISEASE

BY J. HOWARD BEARD, A.M., M.D.

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The creation of new industries, the discovery of new processes, the substitution of steam for water power, the evolution of refrigeration, the development of transportation, the almost universal utilization of electrical energy in the mechanical arts, the extensive use of artificial light, the employment of the Röntgen rays as a diagnostic and therapeutic agent, the overcrowding in manufacturing centers and factories, and the strenuousness of modern life, have brought new problems to industrial hygiene.

Some of the occupational diseases are due to the avarice of the capitalist and his disregard of human life, but indifference, carelessness, and ignorance of the workman are responsible for much preventable illness. Many occupations, while not particularly dangerous, may be rendered hazardous through intemperance, and some industries may be held responsible for impaired health entirely due to the unsanitary and bad habits of the individual.

The United States is far behind many European countries, especially Germany, in safe-guarding the health of her workers. The industrial legislation in America is extremely fragmentary and far from being abreast with our civilization. We have each year about 500,000 industrial accidents, one-half of which might be avoided. We have also 13,500,000 cases of occupational sickness and an estimated loss to society of $772,000,000, and of all this loss we can prevent, at least, 25 per cent.

We note with pride that, in this country, the state of Illinois has been a pioneer in the study of industrial diseases. The report of the Illinois Commission on Occupational Disease was a very important contribution to the literature of Industrial Hygiene, and the laws of this state, while by no means ideal, are much superior to those of a majority of her sister states.

The workers in industries involving the use of lead, phosphorus, arsenic, mercury, copper or brass are especially liable to poisoning; the same is true of those forced to breathe poisonous gases, such as carbon monoxide, carbon bisulphide, and hydrogen sulphide; there is increased risk of life and limb in aviation, land and water transportation, mining, the handling of explosives, smeltering, and structural iron work; there is particular danger to those compelled to work in a dusty atmosphere, especially if the dust is irritating and poisonous; wool sorters are likely to acquire anthrax, miners hookworm disease, and hostlers glanders; laundry workers, cooks, firemen, and masons often have eczema;

workers in compressed or rarefied air, or in extremes of heat or cold, frequently become ill; and those who handle tar, paraffin, and anthracene may often develop cancer of the skin.

Each occupation presents for solution a separate hygienic problem and each industry requires individual study. It is obvious that in an article of this type we can discuss briefly, only, a few of the more common diseases of occupation.

Lead Poisoning

The evil effects of lead have been recognized for centuries. There is evidence to indicate that lead poisoning or plumbism was known to the earlier Greek and Roman writers, and Galen (130-201 A. D.) knew of the danger of drinking water that had passed through lead pipes.

Plumbism is the most prevalent and most serious of all industrial diseases due to poisoning. Lead attacks young adults with especial rapidity and severity, and women are more susceptible than men. In about 150 trades lead is present, silently and insidiously undermining the health and strength of those engaged in its use.

All lead is poisonous, but metallic lead is not so dangerous as its salts, and of its compounds the most to be feared are the oxide, carbonate, and chromate, because they are more soluble in the human body and most used in the industries.

Lead is absorbed principally by the alimentary tract, but also through the respiratory tract and possibly through the skin. It reaches the stomach with the food or tobacco that is handled with dirty fingers, or by dust which is partly swallowed and partly drawn into the lungs. The danger in a lead trade is in proportion to the dust.

Individuals vary greatly in their tolerance to lead; one person may show symptoms of intoxication in a few days or weeks, while another may be free from signs of poisoning for years. Oliver has demonstrated experimentally on animals that alcohol predisposes to an attack of plumbism, a fact repeatedly confirmed by the clinician. Another factor which favors saturnine poisoning is working in lead before breakfast. A workman with food present in the stomach runs less risk of poisoning than his fasting comrade.

Lead is a typical cumulative poison, giving rise to a chronic intoxication characterized by diminished secretion of saliva, metallic taste in the mouth, foul breath, loss of appetitie, indigestion, headache, constipation, vomiting, and frequently acute colic. Should the workman continue at his trade, more severe

symptoms, such as extreme pallor, loss of weight and strength, impaired vision, or rheumatic pains may occur; the nervous system may be involved, giving rise to convulsions, hysteroid attacks, insanity, or partial paralyses of which "wrist drop" is the most common, or there may be progressive hardening of the arteries and kidney disease ending in cerebral hemorrhage and death.

The blight of lead does not end with the individual alone, but it destroys the reproductive powers of both men and women, and produces a marked tendency in women to abortion, thereby causing great destruction of human life. The percentage of still-borns is large and the children of lead workers within the first few months of life have a high rate of mortality.

Those most frequently afflicted with lead poisoning are makers of white and red lead, lead paints, storage batteries, pottery and earthenware, dry colors, file cutters, painters, plumbers, enamelers, diamond cutters, polishers of cut glass and precious stones, printers, type-setters, and varnishers.

Prevention

The prevention of lead poisoning depends upon the avoidance of dust, the proper disposal of fumes, and absolute cleanliness.

Youths and women should not be permitted to work in the more poisonous industries.

The workmen should be compelled to wear overalls which should be kept at the factory, and these should be washed at the shop, preferably by machinery, for washerwomen may be poisoned by handling such clothes. The head should be protected by a cap.

Personal cleanliness of the workmen should be demanded and proper facilities for bathing should be arranged by the employer, and it should be a part of factory discipline for the workers to take a bath at least once a week, while those engaged in dusty work should be required to bathe daily.

The hands and nails should be thoroughly cleansed before leaving the shop and before taking food. The mouth should be rinsed before eating and the food should be eaten outside of the shop in a room especially provided for the purpose. Each workman should have three meals a day and alcoholic beverages should be excluded absolutely.

Workers in the presence of lead dust should wear respirators and the dust should be controlled whenever possible by spraying with water.

Workmen should alternate employment and not remain long

in the dangerous departments. Machinery should be used in the place of men wherever possible, and a competent medical inspector should be employed to educate the workmen and to detect poisoning in its incipiency.

Phosphorous Poisoning

Two kinds of phosphorus are known to commerce—the white or yellow, discovered by Brandt in 1669, poisonous and inflammable; and the red, discovered by Schröter in 1845, comparatively non-poisonous and non-volatile. The red is obtained from the white by heating for some time in a closed vessel at 250°C.

Phosphorism began with the invention of the lucifer match by John Walker, the dispensing chemist of Stockton-on-Tees about 1827. The first authentic case of phosphorous necrosis was reported by Dr. Lorinser, a Viennese physician, in 1838.

Three types of matches are manufactured: (1) the safety match, which contains no phosphorous and is harmless; the paste applied to the box contains red phosphorous and antimony sulphide; (2) the "strike-anywhere match" contains white phosphorous in its head; it is in the manufacture of this type of match that the workers are exposed to the poisonous fumes; (3) the "strike-anywhere match" made with the non-poisonous sesquisulphide of phosphorous. Until recently all the "strike-anywhere" matches were made from white or yellow phosphorous.

Chronic phosphorous poisoning manifests itself generally as a necrosis of the jaw, which is commonly known as "phossy jaw." It may, however, give rise to such constitutional symptoms as pallor, dyspepsia, tendency to bronchitis, or excessive brittleness of the bones.

"Phossy jaw" is produced by the absorption of fumes and particles of white phosphorous through the teeth or gums. Carious teeth predispose to necrosis of the jaw, for the fumes penetrate such teeth and readily induce a periostitis or acute inflammation of the jaw bone. The gum becomes swollen and the jaw becomes extremely painful, pus forms, the process extends to the bone, which gradually undergoes destruction. The disease may terminate by the decayed bone being thrown off or the dead bone may be removed by the surgeon. In some instances complications and death follow "phossy jaw."

The sesquisulphide of phosphorous introduced into the match industry by Sevène and Gahan is practically non-poisonous and will accomplish all that white phosphorous does without giving rise to its dangers. In some instances, the sesquisulphide of phosphorous will cause conjunctivitis, swelling of the eyelids, and

eczema of the skin. These ill effects may be prevented by bathing the eyes and douching the nose with an alkaline solution of sodium bicarbonate.

Fortunately for the workers in many countries, the use of poisonous phosphorous has been prohibited by international treaty or national legislation.

Prevention

Phosphorous necrosis should be prevented by the total abolition of white phosphorous in the manufacture of matches and by the substitution of the sesquisulphid or some other non-poisonous compound of phosphorous.

The work room should be large, light, and well ventilated and fans should withdraw all fumes away from the workers. Automatic machinery should be used whenever possible.

Personal cleanliness is imperative and ample lavatory accommodations should be provided at the factory. The mouth should be rinsed at least once a day with an antiseptic wash.

All employees should frequently undergo dental and medical inspection.

Mercury

Occupational poisoning due to mercury has been known for many years in connection with the workers in the quicksilver mines of Almaden, and more recently in the mercury miners of California.

Mercury exists in nature in the form of cinnabar, a sulphide of mercury, from which the metal is obtained by roasting. During the process the mercury undergoes volatilization, but is quickly condensed forming droplets that are deposited upon the lips, the beard, and hair of the workmen. The metal volatilizes at low temperature and it is this property that makes it such a menace to the health of the workers.

Mercury enters the body through the alimentary and respiratory tracts and is absorbed by the skin.

The symptoms of mercurialism are metallic taste, ulceration of the gums, headache, fetid breath, excessive salivation, vomiting, intestinal derangement, pallor, emaciation, weakness, melancholia, and in some instances general paralysis. One of the most striking features of the disease is the peculiar tremor commonly known as the "shakes."

The more common occupations in which mercury is used and chronic poisoning occurs, are the extraction of gold and silver from their ores by the amalgam process; the use of acid nitrate

of mercury in the making of felt hats and the dressing of furs; the manufacture of thermometers, barometers, and electric meters; the making of explosives; and the use of the mercury pump in the production of a vacuum in the manufacture of incandescent lamps.

The prevention of mercurialism depends upon good ventilation, means to keep the dust and fumes away from the workmen, scrupulous cleanliness, frequent ablutions, the wearing of overalls and rubber gloves to prevent absorption through the skin, the use of respirators, and working in a room at low temperature to reduce volatilization.

Arsenic

Arsenic endangers the health of the workers in the manufacture of wall papers and artificial flowers; in the preparation of chemicals, especially Scheele's and Paris Greens; in the making of glass and oil-cloth; and in the packing of white arsenic and the curing of furs.

The symptoms of acute poisoning are difficulty in swallowing, violent colic, intense thirst, and a diarrhoea not unlike that of cholera. Chronic poisoning may cause loss of appetite, nausea, vomiting, conjunctivitis, pigmentation, eruption and ulceration of the skin, bleeding gums, cerebral disturbances, neuritis, and paralysis.

The prevention of industrial arseniasis is the counterpart of the protection against saturnism and mecurialism.

Carbon Monoxide

Carbon monoxide is a colorless, tasteless, inodorless, and highly toxic gas. It is caused by the incomplete combustion of illuminating gas, of coal and of explosives, and may be found in mines and other subterranean galleries where blasting has been done with dynamite or gunpowder. The gas is produced in the smelting of iron ore with coke and lime; it is given off in large quantities from coke ovens; it is generated in the preparation of soda by the Le Blanc process; and forms 7-10% of illuminating gas and about 30% of water gas.

Carbon monoxide has greater affinity for the haemoglobin of the blood than oxygen. To this power of displacing the oxygen in the blood the gas owes its poisonous properties. The presence of such small quantities as 0.1% will produce toxic symptoms, while 0.4% renders the atmosphere dangerous to animal life.

The inhalation of carbon monoxide causes giddiness, headache, throbbing of the temples, ringing in the ears, lassitude, marked

muscular weakness, and in severe cases, convulsions and unconsciousness.

The prevention of CO poisoning consists in free ventilation; the use of closed top blast furnaces; leak proof furnace walls; automatic charging; conduction of gases in mains above ground; the elimination of "pits" in which the gases may collect; oxygen helmets for use in the most dangerous places and for rescue work; and education of the workmen in regard to the dangers of their occupation.

Dust

Dust is a great destroyer of workmen. Much ill-health and many of the industrial diseases are due to the inhalation or swallowing of dust. Such soluble dust as lead, phosphorus, mercury, and arsenic may produce serious poisoning, and the insoluble dust of iron, steel, marble and granite may cause mechanical injury to the respiratory tissues. Dust of all kinds is met with in the various trades, but, as a rule, organic dust is less irritating and injurious than inorganic dust.

Dust is given off during the drilling of stone; all forms of grinding; the packing of pigments; many processes of polishing and cleaning; in the manufacture of pottery and masonry; in mining; in the preparation of lumber; in the cotton, wool, silk, and jute industries; and in the handling of leathers, skins and feathers.

In the various pneumokonioses or lung diseases due to the inhalation of dust, the termination is fibroid phthisis, a condition in which the lungs, instead of remaining soft and spongy, become firm and indurated and unable to perform their function as organs of aeration.

Wood and arsenic dust may be especially irritating to the eyes, and soot or arsenic particles may cause skin irritation and predispose to cancer. Dust impregnated with the anthrax bacillus or its spores may produce a fatal infection (wool-sorter's pneumonia.

Much of the injurious effects of dust could be avoided by good ventilation; the use of moisture and sprays; working under water when practicable; the judicious use of hoods and suction fans; the wearing of respirators; and the utilization of improved machinery.

Mining

Mining presents a sextet of evils: (1) the loss of life and limb by accidents and explosions; (2) the poisoning by gases, especially carbon monoxide; (3) the menace of dust; (4) the

liability to ankylostomiasis or hookworm disease; (5) the bad effects of working at high temperatures; and (6) certain local injuries peculiar to the occupation.

The introduction of modern methods; the improvement of ventilation; the control of dust; and the introduction of means to detect and guard against poisonous and explosive gases, have greatly diminished the hazards of mining.

In mining, as in many other occupations and professions, the hookworm infection remains a rather unattractive monument to our retarded sense of sanitation. With the St. Gothard tunnel as a focus of infection, the disease has been widely disseminated in Europe, and from the report of Dr. Stiles, Government Zoologist, we are informed that in the Southern and Middle States, it occurs with almost self-questioning frequency.

An infected miner will discharge myriads of ova in his feces, which in a few days, at a suitable temperature, will develop into active larvae, which may gain admission to the human body through food or water, owing to the miner eating with dirty hands, or they may penetrate the skin, enter a small vein, reach the right side of the heart and thence by the pulmonary artery to the lungs. Through the walls of the pulmonary capillaries they escape into the alveoli, thence by their gliding and lashing movements up the bronchi to the glottis, and then pass down the esophagus and stomach to reach the small intestine, the goal of their desire.

In passing through the skin, the worms give rise to considerable irritation, a condition commonly known as "ground itch" or "bunches."

Once in the intestine, the worms fasten themselves to the wall, and by sucking the blood of the host; the production of small hemorrhages; the making of minute wounds, through which infection may occur; and possibly by the elaboration of a poison peculiar to the parasite, they cause a train of symptoms characterized by extreme weakness, difficulty of breathing on slight exertion, palpitation of the heart, anaemia, etc.

The control and prevention of hookworm disease depend upon the proper toilet facilities and disinfection of the feces; examination of the stools of all suspected and new miners; the miners should wash their hands thoroughly before eating; and the workmen should receive instruction in the life history of the parasite, so as to intelligently cooperate with the medical officials of the mine.

The effects of working in mines at high temperatures are throbbing of the head, increased pulse rate, disturbed breathing,

physical exhaustion, and, in some instances, loss of memory and insanity.

It is exceedingly difficult to overcome the dangers of mine heat, as it is due to the internal heat of the earth. The difficulty of the problem is at once apparent when we observe that some of the silver mines of Nevada have a depth of 2,000 feet and a temperature of 158°F.

In the high temperature mines, at the end of the shift, the men are brought to the surface fatigued and perspiring, and the sudden chilling of the body is another factor in the production of the high death rate of miners from lung diseases. Much of the evil effects of sudden change to low temperature could be avoided by providing rooms at the shaft heads in which the men might change their wet for dry clothes and receive hot coffee.

Miners suffer from a painful chronic irritation and thickening of the subcutaneous tissues over the knee and elbow due to frequently resting upon or knocking these joints, a condition known as "miner's knee" and "miner's elbow." As the result of the continued friction of the pick handle, the skin of the palm along the base of the fingers of both hands and the ball of the thumbs become hard, horny and painful. Such a hand is called by the miners "beat hand." Occasionally suppuration takes place in the deeper layers of the hard skin, giving rise to "keens."

Electricity

Contact injuries are of two types—shocks and burns. The shock may be graded in its effect from slight unpleasantness to instantaneous death. The voltage may produce such tetanic contraction of the flexor muscles that the victim will be unable to release himself from the circuit. In such instances, the rescuer should break the circuit at once by a switch, if practicable; if not, he may push the victim away with a dry piece of wood, a tool with a dry wooden handle, he may pull him from the circuit after putting on rubber gloves, or the rescuer may stand on a dry board and break the contact. A short circuit may be made by using a chain, an iron bar or a pipe. In short circuiting in cases of high voltage great care should be exercised lest an arc be formed which might seriously burn the rescuer and further injure the victim. In breaking the contact by short circuiting great precaution must be observed by the rescuer that he does not expose himself to shock.

Unless the patient shows signs of consciousness, artificial respiration should begin the instant he is released and should be

continued until recovery results or a physician announces that death has occurred.

Shock may cause temporary or prolonged syncope accompanied by weakness, headache, palpitation of the heart, mental confusion, tremor, or general nervous depression. Hysteria and neurasthenia are not uncommon sequelae of electrical shock.

In burns due to electricity, there is usually a destruction of both layers of the skin, subcutaneous tissues, and frequently the muscle and bone are involved. The complications of burns are nervous shock, suppuration, and gangrene.

All electrical burns should be treated by a physician to insure asepsis and antisepsis. The slight injuries may be treated while the patient continues at work; the more severe cases should enter the hospital.

In the breaking or short circuiting of currents, flashes or arcs may be produced which may cause serious injury to the eyes due to the burning and the action of the ultraviolet rays. Flashed eyes are characterized by conjunctivitis, intense pain, intolerance of light, and excessive secretion of tears. In severe cases the cornea may be coagulated, iritis ensue, or blindness occur. Flashed eyes should be treated by an opthalmologist.

The X-Rays may produce redness, atrophy, vesiculation, sloughing, and a predisposition to cancer of the skin. Röntgenographers are likely to become sterile unless they protect themselves by sheets of metallic lead.

Those working with electricity should be taught the hazards of their occupation, the rendering of first aid to the injured, the breaking of contacts, the resuscitation by artificial respiration, the prevention of flashes, the dangers of the ultra-violet and X-rays, and the precise use of rescue apparatus.

Cancer

Cancer occurs in all walks of life and its etiology is unknown, but there seems to be a definite relation between its causation and long continued irritation. This is especially true in the case of chronic inflammation of the skin, be it due to actinic, chemical, thermic, bacterial, or mechanical agents. Owing to the irritation of soot, chimney sweeps have a higher death rate from cancer than the general population; gardeners who use soot to protect plants against insects occasionally develop cancer of the hand; men who work with tar, paraffin, anthracene or scarlet R. seem prone to have cancroid ulcers of the skin; malignant disease is rather common among actinographers; and it may follow the keratoses of lead and arsenic workers.

Ulcers of the skin in workers with these skin irritants should

be regarded as precancerous lesions and should not be neglected. If the condition is a simple ulcer, it will heal if properly treated and protected from further injury. Should it show no signs of healing after a few weeks' careful treatment, it should be extirpated.

Each occupation has its own hygienic problem which should be solved with the greatest safety to the workman and with justice to the employer. To accomplish this end, each industry must be investigated from a hygienic, economic, and sociological viewpoint by experts in these departments of science. After careful studies have been made, the facts should be given to the public, in order that an intelligent and unbiased public sentiment may be formed which will give expression to itself in scientific and beneficial legislation.

In considering the great problems of industry, both capital and labor will do well to remember that of all the instruments used in the production of wealth and happiness, none is so delicate, so sensitive, and so indispensable as the human machine; the employer, therefore, will be using excellent economy in preventing it from being injured by dust and corroded by chemicals. The employee is bound by sacred duty to avoid everything that may interfere with its endurance and precision, in order that it may render maximal service to his employer and be of the greatest blessing to mankind.

GLEANINGS FROM THE EXAMINER'S DESK

The economizer is used for economizing steam.

Refraction causes something to be seen after it has actually gone out of sight.

The Law of Charles is not very important, as they have been tried time and again and have been proven untrue.

The economizer is a condenser.

Lap is the name given to that portion of the rotation when steam is admitted before completion of stroke.

The governor regulates the steam flow through the eccentric.

Indicated H. P.—total energy in the steam as it enters the cylinder.

CITY MANAGEMENT AND THE CITY MANAGER

BY H. W. MILLER

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It is the purpose of this article to present merely a somewhat superficial discussion of the problem of city management and not a statistical account of what has been accomplished under any certain methods.

During the last few years a few cities of the United States have been trying the experiment of placing the administration of their affairs in the charge of one man chosen, not by popular election, but for his qualifications as a manager of such affairs and with the understanding that he devote his whole time to the duties of management and be held strictly responsible for the results, just as the manager of any commercial organization. It is too early in the game to make any very definite statement on the working of this scheme as compared with our time-worn scheme of elective selection of city officials, mayor, etc.; or the more recent scheme of commission government.

There is a phase of all this movement that appeals very strongly to one who is analytically inclined. During the last thousand years methods of managing public affairs have been dressed in many guises, but actually have seen about as much real progress as the profession of law. We created an executive office which should be responsible for the proper administration of the affairs of the city; this was correct. But we have been electing men to fill that office with practically no thought of their qualifications for administrative work; a doctor, lawyer, or merchant perhaps undertakes such duties for the first time in his life when he becomes the mayor of a city. Likewise we elect to many of the city offices men concerning whose qualifications for the work which they will be required to do we have given practically no thought. This is not true in the case of every office, for in some cases the special duties so plainly call for certain qualifications that we choose the men with great care. This whole procedure when viewed in a commercial light is, to put it very mildly, most absurd.

In any commercial organization there is but one way to obtain results that are at all commensurate with the money invested; that is, to place in complete charge of all departments one man who is, first, a competent administrator; second, qualified by training to understand thoroughly all the details of his organization, and if necessary to create the organization; third, to have him give his whole time and attention to this one job and hold

him responsible for results. This is true of any commercial organization, no matter what the nature of its business, whether it manufacture shoes, build railroads, dig canals, or pave streets.

On examination of the duties of the executive of a municipal organization one finds himself hard put to detect any difference whatever between them and the duties of the general manager of a manufacturing company. Why we have been so long in deciding upon the proper method of handling public affairs is rather difficult to say, and perhaps it is a waste of time to speculate about the reasons. Now that the scheme is being tried, it is interesting to consider the type of man, both by education and natural qualifications, which is best able to fill the position of city manager. The duties of the office are:

To see that the laws and ordinances are enforced.
To exercise control over all departments.
To direct the work of all appointive officers.
To employ and dismiss all city employees.
To superintend the construction of public works.
To approve or disapprove requisitions for purchases by any city officer or department.
To attend all meetings of board of trustees.
To recommend to the board of trustees for adoption such measures as he may deem necessary or expedient.
To keep the board fully advised of financial condition and needs of the city.

Included with the administrative ability required to discharge these duties must of course be the ability to understand thoroughly the details of the work of each of the sub-organizations of the city: street maintenance, lighting, building regulation, fire protection, drainage and sanitation, etc.

Commercial organizations seem to have decided that the ablest manager is found in the man who possessses the required administrative ability and a general engineering education; by general we wish to differentiate from the highly specialized education. During the last few years the companies that have sent representatives to the University of Illinois for men have in most instances stated that they wished to train these men into managers. From a glance at the duties and requirements of a manager of municipal affairs it seems that if there is one special type of management above others for which the civil or municipal engineer would be fitted it is this. Likewise that this is the one type of management the special duties of which demand an engineer. The engineer manager is familiar with the practical solutions of many of the city's problems; his training has made

him a wide-awake, open-minded investigator, a man whose dominant idea as an engineer is that to be a success he must be the most progressive man in his organization. His very profession has trained him to keep his own work and the work of all of those under him in the open, where it may be inspected and criticised. Reports and records are always an important part of his routine work, and above all, if he is a true engineer his methods and results are always compared with those of others and judged by himself from but one standpoint, that of efficiency.

"The ideal instructor, even in a technical subject, is not necessarily the greatest expert nor the keenest investigator, nor the most skilful teacher. In these respects he must, of course, command respect. But the ideal instructor must be nothing less than the ideal *man*. With such *men* imbued with this *spirit* every technical school would do far better work than they have heretofore been permitted to do, because of the limitations which have been traditionally put upon such schools. . . . . If the trained technical man is to discharge his obligations to society aright, it will be because the technical schools of our land and of the whole world awake to the fact that they must give to the world, not technical men but technical MEN.

Frederic W. Speirs,
A graduate of a technical school and at one time
Editor of *Booklovers' Magazine*.

GLEANINGS FROM THE EXAMINER'S DESK

Energy is negative work.

Total heat of steam is the total number of dry steam which may be turned into B. t. u.

The condenser injector governor is used to control the amount of steam admitted to the condenser, and also the amount of water which is admitted, thus assuring perfect condensation.

Unit of power is that unit which will furnish one lb. in 1 sec.

Unit of work= ft. lb where 1 B. T. U.=778 ft. lb.

The lead is that amount which is given by which the steam can again begin to act.

SELF-PROPELLED RAILWAY CARS

BY RAYMOND S. ZEITLER

(Mr. Zeitler is a Mechanical-Electrical Engineer employed here by the Japanese Government assisting in designing and building their new Dynamometer Car. He was formerly connected with the Engineering Staff of the Northwestern Elevated Company of Chicago, and has been employed in similar capacities by various companies.—Editor.)

Nearly every forward movement in industrial progress comes after a cycle of efforts and failures to make of practical use new and progressive ideas. These cycles usually represent the premature introduction of devices, their extremely slow economic development or utter failure and abandonment; then a later resurrection and adoption. The self-propelled passenger railway car is a striking example of a much needed unit, which for many years eluded the best efforts of railway authorities and engineers, but which has at last emerged into a practical field.

The advent and phenomenal success of the trolley car seemed to urge pioneers in the development of the gasoline car to a prompt introduction on steam roads of their much heralded independent unit, designed to give steam road passengers the comfort and modern convenience of electric traction. But in spite of unlimited financial and railway support, and sympathy and encouragement of an expectant public, this forerunner of a now successful and necessary type passed into oblivion.

Various solutions of the problem were sought, all sources of power were used, such as high pressure steam, compressed air, storage batteries and motors, but finally resorted again to the internal-combustion engine, both mechanically and electrically connected to the driving wheels. Without entering into the history of the early development of the many experimental cars built, it can be said that the advantages of the internal-combustion engine in operation, maintenance and field of operation are so marked that this article will be confined to the latest and most approved railway cars driven by this type of prime mover. Internal combustion engines have been built which will use fuel in any of its three forms—solid, gaseous or liquid. The use of solid fuel, however, has not been placed on a successful commercial basis, and gas fuels, while entirely satisfactory, are prohibited by the conditions of motor-car operations, as the gas must be carried in demountable tanks and a supply maintained along the line or must be manufactured in some kind of a gas producer in the car. These methods limit the radius of operation of the car and introduce complications which prevented the successful operation of steam and compressed air cars.

Liquid fuel avoids these limitations. The internal combustion engine using this form of fuel is well known and has proved entirely satisfactory. To the high perfection of this type of engine all credit should be given to the automobile industry, also to the latest mode of transportation, the art of flying, which has brought many great improvements and refinements to the internal combustion motor. Liquid fuel offers many great advantages in methods of storage and handling and can be obtained with a greater heat value, weight for weight, than any other fuel. As an illustration of the economy of this type of fuel, it is to be noted that gasoline cars of from 30 to 50 ton in weight, in actual service on steam lines, are carrying an amount of fuel which is equivalent to a radius of operation of 300 miles without recharging, and that including the weight of water for cooling cylinders, the total fuel and cooling medium does not exceed 2,500 pounds.

The popularity of the internal combustion engine being due to gasoline and naphtha, it is natural that this fuel should be resorted to for use in railway motor cars, and therefore the cars under consideration have become known as gasoline railway cars. From the historical standpoint the successful application of this type dates from the modern development of the gasoline engine and is therefore comparatively recent. At this point, the few successful types may be classed in two groups, according to their methods of transmitting the power from the engine to the wheels.

1st. Gasoline cars with electrical transmission to the axle, known as Gas-Electric Cars.

2nd. Gasoline cars with mechanical transmission to the axle, known as Gas-Mechanical Drive Cars.

Gas Electric

In the Gasoline Electric Cars the engine is directly connected to the generator and the power is transmitted electrically to the motors, which are geared to the driving axles. The engine and generator are mounted inside the car at the front end, in what is known as the engine room. This type of car is nearly always built for single end operations; the controller and electrical equipment being placed in the engine room, likewise a small air compressor, which furnishes air for both the brakes and starting the generator engine.

The first successful or important installation of the Gasoline Electric Car was begun on the Arad-Csanad Railway in Southwestern Hungary. A service begun in 1905 has grown from 34 trains daily under steam service to 144 trains with the gas-electric

operation. The fares were reduced about one-third, but the receipts have constantly grown. Where a severe deficit existed under the steam service, the gas-electric brings a net surplus of between forty and fifty thousand dollars per annum. The cars used by this road are of light construction, having power plants of only thirty-five H. P. and seventy H. P. giving an average efficiency of only 65%. Although this efficiency seems very low, the results speak for themselves.

The most widely known Gas Electric Car in the United States are those manufactured by the General Electric Company of Schenectady, New York. This car is built to a standard design, being of all steel construction, rounded front end and with either a side or end entrance. The power plant consists of an eight cylinder, four cycle, 150 H. P. engine of the V type directly connected to an eight pole, 600 volt commutating pole generator. The power plant is located at the forward end of the car, and occupies a space of approximately 12 feet in length. The electric drive from it permits the use of a smaller wheel base than with the mechanical drive type and therefore more readily adopted for interurban operation with its small radius curves. This company now has about 60 of these cars in operation in the United States.

In addition to the General Electric Company's is what is known as the "Dra-Car," manufactured by the Drake Railway Automotrice Company of Chicago. This company had charge of the installation on the Arad-Csanad Railway and have built cars for many other European railways. Their engine is a 7 cylinder, areoplane type directly connected to the generator, imported from France. Their generators were designed by the French Westinghouse Company. This company has furnished five cars to the Missouri, Oklahoma and Gulf Railway and reports orders for a number of others. Their standard car is fifty-six feet long over the bumpers and nine feet six inches in width, and is divided into different compartments according to the requirements of the railroad company, with the engine compartment at the front end. A few remarks here might be in place in this connection upon a type of car which has been to some extent and which still seems to be advocated; that is, combination of the gasoline electric car with the storage battery auxiliary. The idea of storing up electricity in a storage battery appears so feasible that some engineers and officers of railroads still ask for this type of car. The fact is that the storage battery is of no real value in combination with the electric drive as it has been developed to-day. The real value of the electric drive lies in the possibility of

working through a wide range of voltage and current, and the idea of using a storage battery with it is based upon a misconception of the meaning of the electric drive. The variable voltage control with a gas electric drive gives the same results as the storage battery auxiliary and with greater economy in weight and power.

Mechanical Drive

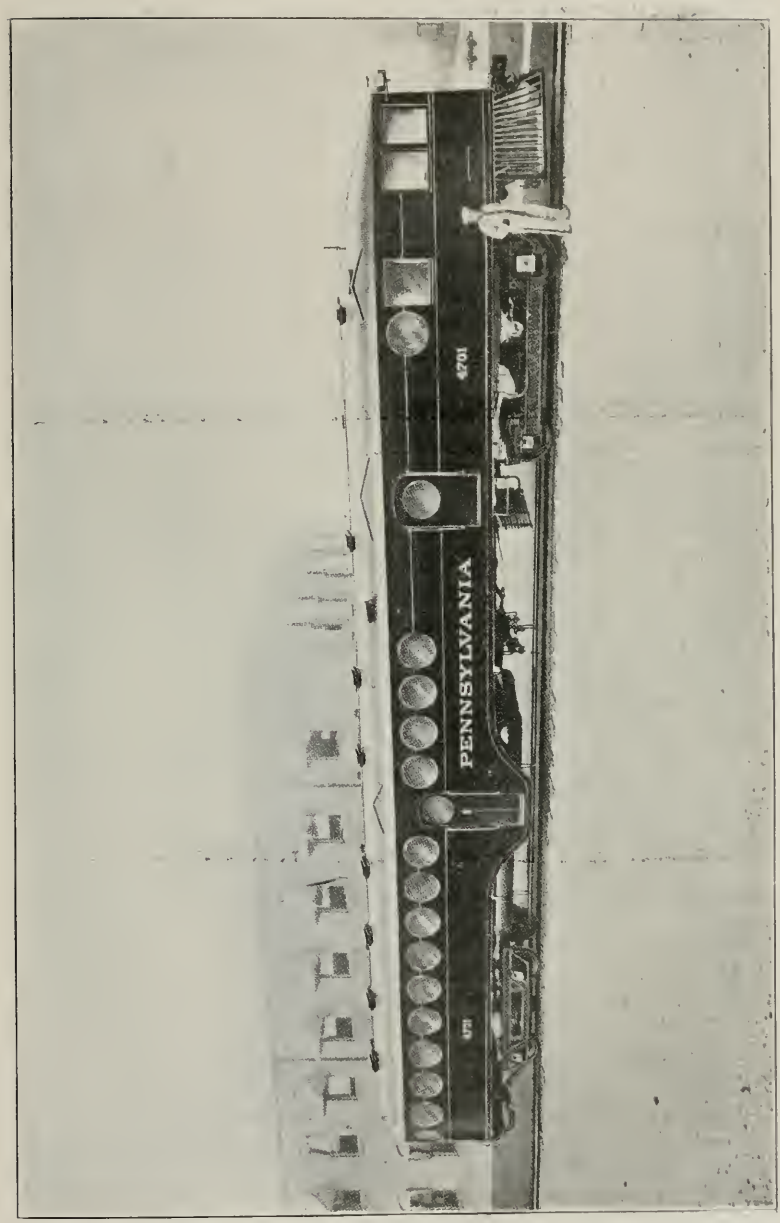
Many smaller and lighter cars, such as inspection, emergency service, etc., are used by the railroads, but this class is outside of the article and will therefore be omitted. Aside from these, the best known and in fact the only Gasoline Mechanical Drive Cars of importance, are those manufactured by the McKeen Motor Car Company of Omaha, Nebraska. The development of this car began in the Union Pacific Railway Company's shops at Omaha, under the direction of Mr. W. R. McKeen, at that time superintendent of motive power. There is now a separate organization under the above name. Their first car was built in 1905. In its latest development the standard car is of all steel construction, from 55 to 70 feet overall length, built with either center or side entrance and a pointed front end. The exterior with its sloping roof, smooth sides, and pointed end gives the appearance of being suitable for high speeds. The interior of the car is divided into engine and seating compartment, either with or without a smoker, baggage or express compartment as desired. The passenger compartment may seat as many as one hundred passengers. It is a double track car having the engine mounted on the front truck in such a manner as to have the cylinders extend into the engine room, thereby permitting the driver or the engineer to attend to any adjustment that may be needed. The engine is a six cylinder, 200 to 300 H. P., according to the length of the car and the work required from it, and is connected to the driving axle by a silent chain, clutch, and suitable gearing. The engine is reversible and is started by compressed air, there being a small air compressor, driven by a single cylinder gas engine, located in the engine room. This compressor also furnishes air for operating the brakes, clutch and gear shifting mechanism. Maximum speeds obtained by these cars are as high as 60 to 70 miles an hour. These cars are fitted with fuel tanks of 100 gallons capacity, equal to about 300 miles radius of operation.

The manufacturers report that in April, 1913, 138 of these cars were in operation on 50 different railroads in the United States and foreign countries. Recently seven of these cars were shipped to Australia; two to the Victorian Government Railways

and five to the Queensland Government Railway. Some of the railroads operating this type of car in the United States are: Santa Fe, Union Pacific, Chicago & Northwestern, Erie, and Pennsylvania R. R. In Europe this type of car has been built by several different companies and are in operation on the Great Western Railways (England), the Swiss Federal State Railway, and the Würtemburg State Railways.

To-day the development of the gasoline propelled cars has touched the steam locomotive field and the Baldwin Locomotive Company are now manufacturing Gasoline Industrial Locomotives with a maximum draw bar pull of 3,500 pounds. Although this seems very small, it nevertheless shows the tendency toward the Internal Combustion Engine Locomotive. The locomotive, however, of the most note is the one built under the direction of Mr. Rudolph Diesel of Munich, Germany. It is operated by a crude oil engine which was designed by Mr. Diesel, giving a draw bar pull of 30,000 pounds. In reference to this locomotive, I wish to quote from an article by Mr. W. R. McKeen, as follows:

"Regarding Mr. Diesel's observations concerning the Internal Combustion Engine Locomotive, it may be said that he unquestionably advances points not thoroughly appreciated or developed. Railroading is a profession. Scientific work in conjunction with wide practical experience is particularly productive of good, beneficial and economical results in railroading, but without this necessary scientific, practical knowledge and long experience an individual is not reliable in development work of new railroad devices and principles. Some requirements are magnified and others minimized, and the distortion of the cardinal necessities is frequently the cause of ultimate failure. Mr. Diesel seems to magnify the task of applying the Internal Combustion Engine to railroad locomotive purposes. In his application of the Internal Combustion Engine to a locomotive his design shows unnecessary and regretable complications, and while a locomotive of such a design could make a very favorable test and demontsration, its trouble would be in meeting with small, every-day hardships of ordinary railroad service conditions. A multiplicity of mechanisms to simplify the operation is not necessarily unjustifiable; on the other hand, undue numbers of mechanisms should be avoided as a general economical railroad principle. A steam locomotive has great flexibility, in case of a little oil, weeds or frost on the track, a little water in the cylinders, too much water in the boiler, destroying the lubrication of the machinery, valves, etc., rods on dead center, small obstruction to the drivers, and various other causes, the draw bar pull is seriously interfered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with and the highest skill of an experienced locomotive engineer is necessary to ease the load on the locomotive in getting started. So with an Internal Combustion Engine locomotive, it is not unreasonable to expect the operator to use some skill in easing the load. Therefore the prime mover should be as simple and direct a means as possible coupled to the driving axles and any serious complications and unnecessary mechanisms should be avoided."

As the main factor which induces railroads to use and operate units of this type of transportation is the financial and economical part, a comparison of first cost, operation, etc., is very essential. In comparing any figures where comparison and operating expenses of different types of rolling stock or motive power are considered, *the greatest problem is to equate the unequal factors or in establishing an equitable and comparable service with the same volume of traffic under the same conditions and with the same earning capacity.* As the volume of traffic is a variable quantity and is stimulated or retarded to quite a considerable extent by the type of power used, it can be seen that this comparison must be very carefully worked out. For example, the Gasoline Motor Car will stimulate more new business than either the electric traction or steam service and under most conditions; yet there are conditions where steam train service, especially on long distances and under spasmodic conditions, will handle more successfully the passenger business than either the gasoline or electric equipment.

Comparison of a 22 mile Interurban operated with Electricity and Gasoline Mechanical Drive Cars:

Investment 22 Miles Track Construction	600 Volt High Tension Electric Installation	Gas Mech. Drive Motor Cars
60 lb. rail @ $10,000 per mile	$220,000.00	$220,000.00
Two Motor Cars	24,000.00	38,000.00
Trolley, Transmission and Feeder Lines @ $3,500 per mile	77,000.00	
Rail Bonding @ $450 per mile	9,900.00	
2 Sub-stations @ $24,000.00	48,000.00	
Power House @ $3,000 per mile	66,000.00	
Total Investment	$224,900.00	$ 38,000.00
Saving in first Investment		$186,900.00
Interest at 5% per year on Investment	$ 11,245.00	1,900.00
Saving in interest by installing Gas Mechanical Drive Cars		9,345.00

Interest per car mile based on Yearly car mileage of 128,480 miles	8.75c	1.48c
Saving in interest per year per car mile by installing Gasoline Mechanical Drive Cars		7.27c

The cost of track construction with 60 lb. rails varies from $8,000.00 to $12,000.00 per mile, depending upon the cost of right of way, cuts and fills, number of bridges and stations required and local conditions. A sixty pound rail is amply heavy for the gasoline car; electric lines, however, are using a much heavier rail, but for this comparison the cost of track construction, stations, etc., can be considered the same for an electric line or gasoline motor car installation, and the cost for 22 miles, taking an average cost of $10,000.00 per mile, would be approximately $220,000.00.

The two gasoline cars included in this estimate are 55 foot, of all steel construction, embodying all modern improvements in construction, ventilation, heating, etc., and each car has a seating capacity of 70. The selling price of these cars is $19,000.00 F. O. B. Omaha.

The price of the Gas Electric Cars to be used under the above conditions is from $23,000.00 to $26,000.00 each F. O. B. Erie, Pa., according to the type of car body selected.

The latest and up-to-date electric trolley cars of semi-wood construction, weighing about 35 tons and seating 60 passengers, vary in cost from $10,000.00 to $16,000.00 each, and for comparative figures it has been estimated that the cost of electric car is $12,000.00 each.

In recent issues of the *Engineering News* and *Electric Railway Journals* have been published some very elaborate detail estimates covering the cost of 600 volt, 1200 volt and single phase electric line and the above figures as to the cost of electric cars, and electric line installation, have been based on the figures so given by electric engineers in the above mentioned magazine. The cost of 600 volts, sixty passenger electric cars is given at $12,000.00 each, sub-stations at $24,000.00 each, rail bonding $400 to $500 per mile, and the trolley, transmission and feeder lines per mile is as follows:

Trolley wires and poles	$2,264.99	per mile
Transmission line	732.57	" "
Feeder line	682.69	" "
Total	$3,680.25	

With reference to the cost of the power house, $3,000.00 per mile is given by engineers as an average price for power houses for electric interurban lines of 100 miles in length. Local conditions,

types of boilers, types of generator equipments, use of turbines or engines, use of condesing apparatus, coal and ash machinery, etc., would govern the cost, and, therefore, the cost of power house and other plants for a 22 mile line, I believe $3,000.00 per mile to be a rather low estimate.

Depreciation

Comparison of depreciation. 600 volt electric installation and gasoline mechanical drive cars:

	Electric Cars		Gasoline Motor Cars	
	Rate per yr.	Amt.	Rate per yr.	Amt.
Rolling Stock	6⅔%	$ 1,600.00	5%	$ 2,000.00
Trolley and Feeder Lines	5	3,850.00		
Rail Bonding	10	990.00		
Sub-stations	5	2,400.00		
Power House	5½	3,630.00		
Total		$12,470.00		$ 2,000.00
Saving per year on depreciation by installing Gasoline Motor Cars				$10,470.00
Depreciation per car mile based on yearly car mileage of 128,480 miles		9.70c		1.58c
Saving in Depreciation per car mile by installing Gasoline Motor Cars				7.12c

The above depreciation figures for electric lines are based on engineering reports and electrical journals, which are as follows:

Transmission Lines	Average	Life	20 years
Sub-stations	"	"	20 "
Trolley and Feeder Lines	"	"	15 "
Rail Bonding	"	"	10 "
Electric Cars	"	"	15 "

Depreciation of power house taken at 5½% is based on the following:

Buildings, etc.	3 %
Boilers	10
Engines and Generators	7½

The depreciation on the gasoline motor car is shown at 5%, which I believe very conservative, in view of the fact that this car is of all steel construction, practically indestructible, that the engine is built for railroad service and amply proportioned. I would call attention to a McKeen Gasoline Motor Car, that after seven years of service made the attractive record of covering 5,000 miles during the past month, earning $117 per day at a total operating charge of 14c per car mile. This is a performance which should interest you. It shows a greater earning efficiency than a passenger train and also shows that the age of the car does not decrease its efficiency.

Cost of operation.

The Gasoline Motor Car in railway service averages three miles per gallon of gasoline, some of the cars making three and one half miles and better per gallon. The total cost of operation in rail-road service where the motorman and conductors are paid the same wages as the steam train crew varies from 16 to 18c per mile and the average cost of operation per car mile is 16c. The detail cost of operation per car mile being a years average for five cars on one of the western railroads is as follows,

Repairs	2.74c	per car mile
Gasoline	4.59	" " "
Motorman	2.99	" " "
Conductor	2.81	" " "
Cleaning	.99	" " "
Oil and waste	.46	" " "
Miscellaneous Supplies	.37	" " "
Total	14.95	

In case the motorman is paid a monthly salary of $125 and the conductor $100, the cost of crew per car mile would be 4.2c.

Running and shop repairs average two or three cents per car mile. With the large and ample proportions of the engines placed in these cars which increases its life, the cost of operation per car mile of 16c is a conservative one for an estimate. Recent reports in Electric Engineering Magazines have shown the operative cost of the modern and up to date electric interurban lines in Indiana, Ohio and Illinois to vary from 19.4 to 20.8c per car mile. These lines have the most efficient power plants, serve large cities and give frequent service, therefore the cost per car mile would be less than on short electric lines.

An electrical engineer showing the detailed cost of operation of electric cars, published in one of the Electric Journals shows the operation and maintenance of sub-station to vary from $2,000.00 to $5,000.00 per year, and the cost of maintenance, of transmission, trolley and feeder line to be from $125.00 to $250.00 per mile per year. Figuring the cost of electric power at 1½c per K.W. per hour which is conservative and using the above lowest figure for maintenance, transmission, feeder and trolley lines, etc. cost of operating electric car per car mile would be approximately 20c. In this connection it is interesting to note that the report of the Railroad Commission shows that the average cost of operating electric trolley roads in the State of Massachusetts, including city lines giving frequent service as 17.2c per car mile, excluding interest and depreciation and the cost per car mile with interest and depreciation as 30.527c.

Therefore taking an average cost operation of 16c per car mile for gasoline motor cars and 20c for the electric we have the following comparison, figuring that each car will make four round trips per day or 176 miles per day, making a total yearly mileage of 128,480 miles.

	Electric	Gasoline
Cost of Operation per Car Mile	20.0 c	16.0 c
Interest on Investment per Car Mile	8.75	1.48
Depreciation per Car Mile	9.70	1.58
Totals	38.45	19.06

Saving per car mile in favor of gasoline motor cars 19.39c. The above saving in operation per car mile by installing Gasoline Motor Cars in place of electric installation would mean a total saving, based on the yearly car mileage of 128,480 miles, of $25,798.78 and therefore the Gasoline Motor Cars will soon pay for themselves.

An awakening sense in traction engineering and operation is rapidly developing along the lines of efficiency and more attention is being paid to the choice of proper elements or machines to perform a given work. The same sentiment and judgment that governs the elimination of heavy grades, causes electrification of difficult sections, should equally control the lesser traction element and those to which the Gasoline Motor Car is more strictly applicable. Any large railway system when spread out in plan represents a net work with feeders or branches radiating from the mains or chief arteries of travel. It is indeed a fortunate railway system whose passenger receipts from feeder and branch lines show a profit over cost of operation. Yet the public must be served, even tho a deficit results from such service.

The average branch line service on the steam roads does not fill a steam train nor does it justify the expenses of running one. Usually these trains are composed of engines and equipment considered obsolete for main line service. The locomotives are notoriously wasteful and often in bad condition. *The branch traffic thus ordinarily represents the most expensive per mile service on the entire road* and for such cases the Gasoline Motor Car offers a wonderful relief and can usually show a profit. The actual operating cost, in contrast with a locomotive is very large, without considering the collateral expense attached to steam service, such as round-house and terminal service, water tanks, and coaling shoots with its attendants, etc.

In the field of electric traction the gasoline car may successfully perform the service of owl cars thus permitting the oper-

ating cost to be greatly reduced. In case of projected extensions, it may be used to develop or demonstrate traffic, that later electrafication may follow. By certain trackage arrangement it could serve as a unit, operating partially on steam railway tracks and then enter and penetrate to civic centers for the accommodation of entire new traffic thus created. No modern development in railroad transportation has awakened such interest or found so large a market awaiting its advent as the self-propelled motor car. The installation of gasoline motor car is the most economical investment and not only is derived an enormous saving in investment and operation, but the gasoline motor car appeals to the public and is a developer of new lucrative business.

GLEANINGS FROM THE EXAMINER'S DESK

When work is done upon or by a body without changing the amount of energy available, a certain amount of available energy is either created or destroyed.

The angle of advance is the angle which the piston has when the ports are closed.

The unit of power is the pound. It equals four time distance without respect to time.

The angle of advance is the opening when the slide valve is at the end of its stroke.

The C. G. S. System of Units is the weight of a cm. acting on a gram for a second.

The water column is to give pressure to the feed water entering the boiler.

PRACTICAL QUESTIONS FOR DETERMINATION IN ADVANCE OF ENTERING BUSINESS

(Abstract of a lecture by Stephen W. Gilman, Professor of Business Administration, University of Wisconsin.—Editor.)

On March 26 Mr. Stephen W. Gilman, Professor of Business Administration at the University of Wisconsin, lectured to the engineering students on "Practical Questions for Determination in Advance of Entering Business."

He emphasized the importance of engineers possessing the business instinct, cultivating tact and diplomacy, and acquiring a knowledge of human nature and commercial problems. The engineer with a commercial bent should use his technical skill as a stepping stone for a commanding position. It should be remembered that big interests in commerce pay the bills of engineers and for engineering enterprises. The engineer possessing an analytical commercial bent and who can analyze financial undertakings and understand the wily schemes of the promoter will make more rapid progress than the one lacking in these points. There are engineers—"technical slaves"—working in buildings in Chicago and New York for less than the janitors in those buildings because they lack the commercial equipment demanded by progressive men.

Prof. Gilman said he would like the engineers to be known as "commercial engineers, not a combination of high lace boots, rough necks and mathematics. Engineers with business heads, with man-of-the-world balance, with commercial and social poise, with mind and body under control, and who have a broad vision."

Engineers will always be in demand by big, powerful interests, but it will be engineering skill with an "appreciation of scientific business organization and management."

Due to the fact that the field of engineering has broadened out in the last few years, technical men should be equipped with a training in business.

In following up this idea Prof. Gilman next discussed the matter of partnerships and the investigation of corporations.

If a partnership, the character of the proposed partners is of prime importance. The fullest possible information regarding them, as their reputation as honorable business men, how they stand with financial people, determination as to whether they have been guilty of irregular practice, must be secured before a partnership is entered into or business performed. To do this it is necessary that the investigator possess the faculty for "scientific

pumping for information." Their personal attributes, involving a study of the human element, must also be determined. This includes an analysis of their personality, determination of whether there will be real cooperation or a tendency to trouble making; determination of whether they are open minded and tolerant, prompt and united in action, free from envy, discontent and criticism; and determination of their fitness to manage people well, to make strong, financial people confident and assured.

The points to be considered in an investigation of a corporation were taken up last and in the following order: Plan of organization and the corporation laws of the state under which organiation was effected. The latter is quite important, as the laws of certain states are very lax, thereby making fraudulent promotion possible. Unusual features in charters and by-laws, commonly called "jokers," should be watched as closely as is done in the case of titles.

Attention was also called to the importance of investigations into property books and financial statements, into the business record of directors and members of executive committees, and to special and peculiar qualifications of officers.

These points were emphasized for the reason that engineers more than almost any other profession are liable to fraud.

In conclusion, the engineers were reminded that he who has the most well-rounded character is the one who achieves after graduation.

WILLIS LERCHE, '14.

MILITARY FIELD ENGINEERING

MAJOR F. D. WEBSTER, U. S. INFANTRY

Professor of Military Science and Tactics

Military Field Engineering, defined, is the art of utilizing the materials at hand for the attainment of security, effectiveness, health, and comfort of an army in the field.

Fortifications are divided into two classes, (a) permanent, and (b) temporary or field. Permanent fortifications are those built in connection with sea-coast defences, and are more or less elaborate. Field fortifications are again subdivided into (1) field works, for the defense of arsenals, bridges, fords, positions, etc.; (2) siege works, devices of the engineer for the reducing and capturing of fortified places by the use of parallels and approaches; and (3) battle, or hasty intrenchments, used by an army for protection in the presence of an enemy.

The purpose of this paper is not to go into the details of Military Field Engineering, but to give a general idea of the relation that it may bear to engineering in general, and more particularly to Civil Engineering as taught at the universities. All civil engineers are trained along certain lines which should make them useful adjuncts to the army in case of emergency in time of war. These engineers in time of war are used for building field fortifications, bridges, roads, railroads, and other such works, but always something that must be done in a hurry, as time is the main element in time of war. "To get there first with the most men" is the one maxim every general should have as his motto. As a rule there are not enough engineers with an army to attend to all the work necessary, and such work then falls on the soldiers, usually the infantry. The only way to defeat an enemy is to seek him out and fight him. The enemy always endeavors to place himself in such a position that to approach him only the hardest road is open to the attack. Especially is this true when he places himself on the opposite bank of an unfordable river and destroys all bridges and approaches. Then comes the duty of the field engineer. He must seek out a place and throw or build a bridge to get the army across the river quickly and in sufficient numbers to defeat the enemy. Oftentimes this has to be done under fire, rendering the task doubly difficult.

According to the Field Service Regulations of the United States Army, every infantry division consists of 19,752 men, divided into nine regiments of infantry, one regiment of cavalry, two regiments of field artillery with forty-eight guns, quartermaster, signal and sanitary troops, pack trains, etc., and only one battalion of engineers. This battalion consists of three pioneer companies, total fifteen officers and 501 enlisted men, and seven-

teen wagons. With each battalion there are six divisions of bridge equipage, four heavy and two light. The heavy divisions carry 225 feet of bridge each, and the light, 186 feet of bridge. With this amount of material, a bridge 1,272 feet long can be thrown across a river which will carry anything in the way of troops, field artillery, and loaded army wagons. The transportation for this material consists of thirty wagons and one hundred and forty mules. When the bridge train is not present, the engineers make improvised floating and spar bridges of various kinds from any and all material at hand.

The course at West Point includes both Civil and Military Engineering. Only a limited number of graduates go into the engineering corps, the remainder going into the line of the army. Those joining the Infantry, Cavalry, and Field Artillery afterwards attend the service schools, taking advanced courses in field engineering, and assume the duties of the engineers when they are not present in the field.

The various duties of the Military Field Engineers may be summed up as follows:

A. To assist in gaining information. Including:
   1. Reconnaissance for routes of communication.
   2. Surveying and road sketching.
   3. Photography.
   4. Map reproducing.

B. To facilitate the march. Including:
   1. Demolition of obstructions on roads, fords, or other routes.
   2. Clearing routes through woods.
   3. Laying out, constructing, repairing, and improving roads.
   4. Marking and illuminating routes.
   5. Improving fords.
   6. Preparing approaches to fords and bridges.
   7. Repairing bridges.
   8. Constructing improvised bridges.
   9. Laying pontoon bridges.
   10. Assisting artillery and wagons through difficult places.

C. To assist in work usually performed by engineer troops from the rear. Including:
   1. Minor repairs to railways.
   2. Laying portable field railway.
   3. Erecting portable bridges.
   4. Ferrying.
   5. Strengthening communications to take heavy traffic.

D. To assist in advance guard action.

PHILOSOPHY FOR THE ENGINEER

BY A. ELMENDORF

Editor The Technograph, 1913-14

The idea of attempting to find a relationship between two subjects as foreign to each other as engineering and philosophy must seem quite absurd to most people. Here are two fields of activity that are as antithetical as night and day, the one dealing with concrete things, materials of construction, methods of manufacture and design, with facts and experience; the other with theory, ideas, and intangible abstractions. There is no trace of similarity between the two, no identity even in part, not even the overlapping that is so evident between the sciences. Engineering, according to the famous definition of Tredgold, is the art of directing the great sources of power in nature to the use and convenience of man. The engineer must devise means for controlling this power, such as canals, dams, engines and generators which serve to produce the necessities or luxuries of daily life. His problems are economic; a desired article shall be produced with the least expediture of energy. Philosophy, on the other hand, concerns itself with the discovery and separation of the underlying realities from the more obvious appearances, and with the source, validity, and unification of knowledge. Material welfare is of no moment. In ethics it wishes to establish comprehensive principles or rules of action which shall guide us in all of our dealings, in logic correct methods of thought are discussed, in psychology the mind as the medium of thought is analyzed. The philosopher is plainly a stranger to the engineer.

Yet foreign to each other as the two fields of endeavor may be, there is a road between them. The moment the engineer changes his question from, *how* shall I reach this end? to *why* reach this end at all? he has placed a foot upon the road to philosophy. A few more similar questions and he is well on the way. Hesitation, doubt, and reflection now characterize his thinking. The primary qualifications of the philosopher show themselves. He may become both engineer and philosopher.

THE ENGINEER A CREATOR OF HISTORY

The contention may be made that the *why* is out of the engineer's province and should not demand his attention; his duty is to do what he is told to do, to produce and not to ask wherefore. A consideration of the consequences of an unquestioning compliance with the demand to get results without weighing the true value of the results will reveal the blunder that such action may

occasion. Where is the rush for results leading to? Can a course blindly pursued lead to a safe harbor? A tremendous responsibility rests with the engineer, greater by far than any employer's claims, for these affect only a few individuals, while the engineer as a class is hewing a path in history of which no one can yet prophesy the goal. The great problems that industrialism has raised, the spreading and cheapening of civilization with its attendant good and evil testify to the engineer's place in creating history. For rapid changes in conditions and environment in which people must live, no period of the past can rival the present. Factories, labor unions, trusts, socialism, million-dollar estates are a few of the consequences of the discovery and development of mechanical power for which the engineer is responsible. History has furnished precedents for many perplexing situations that have arisen so that those confronted with the difficulties found counsel in experience, but there never has been a period analogous to the present to guide the reformer in his attempts at readjustment. Whether we enlist with the optimist who sees before us nothing but a bright light so dazzling in its brilliancy that we are blinded and must have time to accustom ourselves to its intensity before we can find our bearings, or whether we join the pessimist who maintains that we are being led into a dark and gloomy forest from which there is no egress, and into which the cheering rays of culture shall never enter, the fact stares us in the face, the engineer has dug a new channel for the stream of history. The deed is done; shall the engineer continue blindly revolutionizing living conditions, or shall he consider and study the ultimate results of his labors with regard to their desirability? If intelligence should guide us in all of our actions, the answer is evident. The engineer again finds himself on the road to philosophy.

THE APPROACH TO PHILOSOPHY

The philosopher-engineer who will dare to pull himself out of the mire of popular opinion and complacent acquiescence by asking for the why, wherefore, and whereto, will be confronted chiefly with the problems of ethics. A little reflection brings him face to face with difficulties that have gauged the mental capacities of thinking men for centuries. Much loose reasoning, using for premises prejudices acquired through years of contact with uncritical minds will become apparent, and the haziness with which many common terms are used will reveal itself. The inclination of the ordinary man to make peremptory statements and sweeping generalizations and to arrive at easy conclusions

will be seen and condemned. A wariness and caution will mark every advance.

Having decided to clear his mind of all detached or unassimilated ideas and to discard all prejudices, the engineer will be called upon to analyze and define many conceptions that are current in conversation, where they are often given a finality and absoluteness that verges on the goal after which philosophers have striven in vain from hoary antiquity to this day. A few of these will be considered here, not with the purpose of presenting a definition as a solution to the problem, for that belongs to the rare philosophical genius, but to expose, so far as it is possible for a person lacking the equipment for penetrating appearances, the difficulties themselves, in the hopes that some engineers may be induced thereby to search for solutions in the works of more learned men. A word of assurance that such a search will prove deeply interesting should be added. He who associates philosophy with the spectacled, shriveled visage of some pedant who knows nothing about things as they actually are in experience and can only recite in a formal and forbidding manner what others have thought, such a person does not know what a wealth of beauty there lies in store for him. How vital, how close to life at all points, how powerful in determining our course of action, how sublime are the truths that the great thinkers have arrived at! At the same time, no one can hope immediately to grasp the ideas presented in the discourse of the wise, for such works are the products of years of profound thought by the most gifted of mortal minds. The terms used are often foreign to the initiate, and the ideas presented are strange. A gradual approach, with the resolution to hear and to be convinced and to accept doctrines which may at first sound absurd and unreasonable, together with patient and persistent application, will yield a priceless fruit. Bearing these admonitions in mind, the engineer who finds himself confronted with philosophic problems to which reflection may have led him is prepared to enter the mysterious realms of metaphysics, logic, and theoretical ethics.

DRAWING UP A PHILOSOPHY OF LIFE

The engineer who has signified an intention to think and to free himself from domination by preconceived and half-digested notions must face many problems outside of his professional work. Because discussion of such subjects as the Kantian categorical imperative will not earn the mighty dollar it may be denounced as useless and unpractical, but this does not destroy its pertinence as a factor in molding the characters of great men

who in turn influence lesser men thereby. Ideas resulting from such discussion can certainly not be cast aside as irrelevant to action. "I attach more importance to men's theoretical arguments than to their practical proposals. I attach more importance to what is said than to what is done. What is said generally lasts much longer and has much more influence," says G. K. Chesterton. Popular opinion stigmatizes philosophic discourse as unpractical and remote from life because its bearing and influence is not apparent. Yet no political or social reform is ever instituted that does not have its source or foundation in some deeper idea or principle which is in this way quite often unconsciously applied by the investigator of the reform measure. Immediate practical issues, while obvious and therefore bearing a semblance of reality, do not concern the thinker, because they hinge upon more fundamental ideas which constitute the real problems. The reformer's *Weltanschauung* or philosophy of life is the motive power behind all the changes he effects.

In drawing up a philosophy of life the mind occupies itself with two principal tasks, the first that of analyzing, which consists of separating, outlining, and clearly differentiating every concept; and then, when every idea is laid bare, its relation to other ideas is studied and a larger organized whole is built out of them as if they were so many building stones each of a certain size or shape and place in a larger structure. The combining of ideas into larger and more complex conceptions constitutes the second and more important step in the formation of a philosophy of life.

WHAT IS PROGRESS?

Assuming that the engineer does reflect, which means that he is uncontrolled by opinions unconsciously formed, how does it come about that his attention is ever directed toward philosophic problems, and what are some of these problems?

If the engineer be modern he must be progressive. This mandate cannot be circumvented. But what shall he do to carry into execution this demand? In other words, what after all is meant by progress? The word evidently implies some standard or ideal which must be clearly seen before the command can have a meaning. If so, then the standard must be set up. "A continual change or movement toward this ideal as a goal," would then answer the question. As an engineer Wm. Ostwald's definition may satisfy him, that progress consists in improved methods for seizing and utilizing the raw energies of nature for human purposes. Improved methods mean efficiency; that is, an increase

in the ratio of useful energy produced to energy consumed. A ratio of unity would constitute the absolute standard.

Being of a reflective turn of mind the engineer will see that there are other kinds of progress, such as moral and social progress, each of which necessitates a standard the realization of which constitutes the ideal. Here then he approaches the region of abstraction. The highest life and the perfect man are subjects upon which men have argued since the birth of philosophy. It would be presumptuous even to attempt to outline a few of the more important views. Those who wish to trace the underlying ideals of life that have influenced so many great men will find such a search extremely interesting. Thus from the call to be progressive the engineer is led into the mazes of philosophic speculation.

THE NEED FOR A DEFINITION OF JUSTICE

Most engineers find employment in large industrial centers where sooner or later they are confronted by the demands of labor unions and socialists. Whether they themselves are required to meet the demands, or whether as managers or superintendents they merely employ the men who ask for better terms, directly or indirectly, the engineer is called upon to give a decision in favor or against the party representing labor. The relations between the employer and the employee become strained, the latter asks for a larger share in the profits of his labors; the former maintains that wages are just, that competition is free and men are at liberty to work their way up to better paying positions if they have ambition. The laborer cannot be convinced of the justice of the present distribution of the proceeds from labor; he clamors for equity, and at the risk of months of unemployment he tries to enforce his demands. This conflict is waged with bitterness and often leads to bloodshed. Neither party can see the other's point of view, both are right, neither is asking more from the other than is his just share. The opposition exists; what can be done? A third, neutral party, may settle the dispute. Where does the difficulty lie when both sides honestly believe that they are acting in full justice? The unbiased observer sees it in the different standards of justice set up by the opposing factions. A calm consideration of the principles involved, using cool reasoning in place of giving the reins to wild emotion, may solve the difficulty. From the particular instance of the laborer's demand for better hours and wages the engineer is led to the broader and more fundamental problem of justice in general, an abstraction which has been given much thought by the greatest thinkers. Such discussion brings out

other problems; for example, if justice be defined as "the respect for the rights involved in the ideal of social manhood," then the ideal of social manhood must be analyzed and a mutual agreement about it must be reached. This again leads to speculation.

INDIVIDUALISM OR SOCIALISM?

In the demands of the Socialists there lies more than an immediate increase in wages or a decrease in working hours. As is well known to those who have made a study of socialistic propaganda, that party wishes to extend the power of government so that it will eventually own all public utilities. Men now are wage slaves, they say, and will continue to be so until they are no longer forced to work under a factory system run by extortionate capitalists. The government must extend its power so that the individual will receive more protection and thru it more freedom. In opposition to the socialists stand the individualists who wish to reduce governmental restraints to a minimum and hope thereby to achieve greater liberty for the individual. Individualism stands for an unattained ideal and should be distinguished from the meaning so often given it by the press as denoting the present day social arrangement attended by so much disorder and confusion. True individualism may be the nominal goal of present conditions but in reality there is a strong drift toward the socialistic state. Which is the more desirable? Socialists with whom the engineer comes in contact urge upon him a decision in favor of either of two opposing views. An intelligent choice requires a thoro study of the ideals upheld and the consequences of their enforcement. He who is willing to think sees a problem here that merits the deepest consideration.

Having thought about each of the problems mentioned and others to which reflection may have led him, and after a careful study of the answers given by learned men, the engineer is ready to outline his own conceptions and to reach his own conclusions. These then are the bricks, with which to build a philosophy of life. Using coherence as a criterion these concepts may now be brought together or eliminated until a perfect and harmonious structure is erected. The building of such a structure and then the living in it is a great goal to which every person may aspire.

A GRAPHICAL METHOD OF DESIGNING A TRAPEZOIDAL FOOTING

BY A. O. BUDINA, '14

University, May 4, 1914.

Editor of The Technograph:

Dear Sir—I have carefully examined Mr. Budina's solution of the problem of designing a trapezoid to accord with certain prescribed conditions. His method is absolutely original, so far as I know, never having found anything similar in English, French or German works.

Very truly yours,

N. Clifford Ricker.

In large buildings which are built up to or very near the property line it is often necessary to provide a special construction for the footings upon which the wall columns rest, so as not to encroach upon the adjacent property. In order to secure a proper footing the wall column and the nearest interior column are usually supported on one combined footing, and if the wall column is more heavily loaded than the interior column, the footing necessarily assumes a trapezoidal shape. The shape of this trapezoid must be such that its centroid lies directly under the resultant of the two column loads and it must be of sufficient size so as not to exceed the allowable pressure on the soil.

The analytical method of determining the shape of such a trapezoid may be found in several of the standard books[1], however the graphical method has some interesting points and it is with this that we are at present concerned. In Fig. 1 we have the conditions graphically represented, the column at VY being in the wall and more heavily loaded than the interior column at X.

There are several graphical methods of determining the centroid of a given trapezoid, one of the most commonly used is that shown in Fig. 2. The sides CD and AB are extended and the length "b" laid off from the point A to L, and the length "a" laid off from the point C to K. These two points are then connected and the point where this line crosses the median line is the required centroid.

Another method is shown in Fig. 3 and is as follows. From C draw a line parallel to the diagonal DB until it intersects the median line extended to G. Then divide the line GH into three parts. The required centroid lies at the one third point from H.

Still another method is to divide the trapezoid into two tri-

[1]Freitag's "Architectural Engineering"; Hool's "Reinforced Concrete Construction," Vol. II.

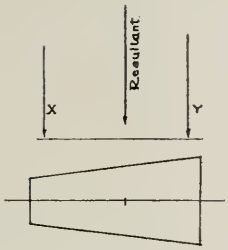

Fig. 1

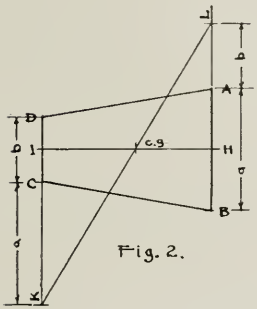

Fig. 2.

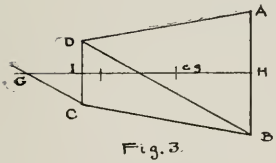

Fig. 3.

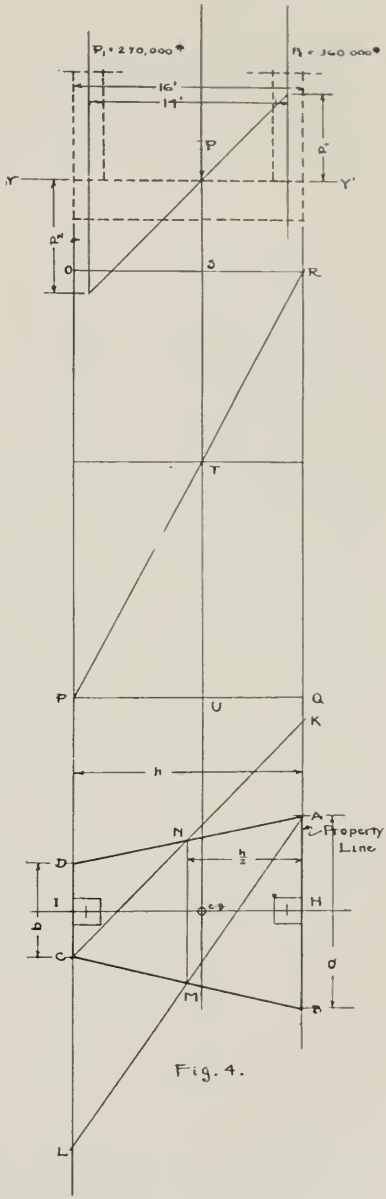

Fig. 4.

angles and finding their respective centroids and connecting them with a line. The point where this line crosses the median line is the centroid.[2]

In the problem in hand the area of the footing is determined directly from the sum of the two loads, the distance between the two columns and dimensions of the columns are known.

Let A = area

h = distance between the parallel sides.

$$\text{Then} \quad \frac{A}{h} = \frac{a + b}{2}$$

The problem then is to divide the sum of a + b into its two component parts, a and b.

For the purpose of illustration the conditions as shown in the upper portion of Fig. 4 were assumed. P_1 and P_2 being the column loads, the centers of the columns being 14 ft. apart and the length of footing, h being 16 ft. The position of the resultant is found by laying off P_2 to scale on the line of action of P_1 downward from the line YY′, and P_1 on the line of action of P_2 upward from YY′. Then drawing a connecting line and the point where this line intersects YY′, marks the line of action of the resultant P.

The line of this resultant is extended as is also the parallel sides of the trapezoid. The center line of the two columns HI is also drawn as shown. From Fig. 2 it is evident that the length IK is equal to $\frac{h}{2}$ + a and that HL is equal to $\frac{a}{2}$ + b and that the sum of HL and IK equals $3\left(\frac{a + b}{2}\right)$. In our case the total load is 630,000 pounds, assuming a safe bearing pressure on the soil of 4000 pounds the area of the footing will be 157.5 sq. ft.

$$\frac{A}{h} = \frac{147.5}{16} = 9.844' = \frac{a + b}{2}$$

$$\frac{3(a + b)}{2} = 29.53'$$

[2]The proofs for these methods may be found in—

"Die Graphische Statik," by R. Lauenstein.

"Die Graphische Statik der Baukonstruktionen," by Heinrich Müller-Breslau.

"Statik fur Baugewerkschulen und Baugewerksmeister," von Karl Zillich.

This length $\frac{3(a+b)}{2}$ is laid off as at SU and the lines OR and PQ drawn in perpendicular to SU. Then the diagonal RP is drawn and this divides SU in two parts, ST and TU respectively.

The distance ST is laid off from H upward to the point K and TU is laid off downward from I to the point L. Then a length equal to $\frac{a+b}{2}$ is laid off symmetrically midway between the parallel sides as at MN. Then a line drawn from L thru M extended marks the position of A which is one corner of the required trapezoid, and a line from K thru N extended marks the position of C, which is another corner of the required trapezoid. Then draw ID equal to IC and HB equal to AH and the entire trapezoid is determined.

It will be seen that AB is equal to CL since ABM and CLM are equal triangles. Likewise AK is equal to CD. This being the case the conditions are exactly the same as they were in Fig. 2.

THE BRIDGE BUILDER

An old man, going a lone highway,
Came at the evening, cold and gray,
To a chasm vast and deep and wide.
The old man crossed in the twilight dim,
The sullen stream had no fear for him;
But he turned when safe on the other side
And built a bridge to span the tide.

"Old man," said a fellow pilgrim near,
"You are wasting your strength with building here;
Your journey will end with the ending day,
You never again will pass this way;
You've crossed the chasm deep and wide,
Why build you this bridge at eventide?"

The builder lifted his old gray head—
"Good friend, in the path I have come," he said,
"There followeth after me today,
A youth whose feet must pass this way.
This chasm that has been as naught to me,
To that fair-haired youth may a pitfall be;
He, too, must cross in the twilight dim—
Good friend, I am building this bridge for him."

ANON.

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THE TECHNOGRAPH, Urbana, Ill.

EDITORIAL

In this, our last issue of the school year 1913-1914, we wish to thank those who, through their cooperation, have helped us make this a red-letter year in the history of THE TECHNOGRAPH. We wish particularly to thank those who, although not in the College of Engineering or even in the University of Illinois at all, have willingly given their time to this paper. We feel that through the continuance of this spirit of free giving of time we can make THE TECHNOGRAPH the equal if not the superior of any college technical paper.

In this issue we have tried to select articles which would appeal

to all the branches of engineering in a popular more than a highly technical sense. We would appreciate our readers offering their opinion at any time, making a note of their ideas and dropping it in the office, Room 100, Engineering Hall. This, we feel, is the only way in which this magazine can become truly representative of the College of Engineering. We ask all members to cooperate with us to further this idea.

HONESTY IN SUMMER READING

To some freshman and sophomore engineers the list of books from which a selection is to be made for summer reading appears to be a device on the part of the University to put into vacation some of the work that should be done during the regular scholastic year. That there is truth in this contention cannot be disputed, for those who have charge of the engineer's course of study realize his deficiencies in the use of English and in his knowledge of the literature of his mother tongue, and rather than let the reading drop entirely, which would otherwise be necessary, they have asked that it be done during the summer months.

Because this work has been put into the months between school years instead of placing it on the regular course of study is, however, no justification for neglecting it or entirely refusing to do it. Other universities require far heavier work than this; one technical school demands a period of five weeks' summer work in the city factories as one of the requisites for its degree. Those men who relieve their conscience in signing the statement, "This is to certify that I have read during the past summer the works in the above list through which a line is drawn," with the thought that the pledge can be interpreted broadly, "the past summer" to mean any time during the past, are simply asserting under oath that they are too lazy to read or that they have absolutely no literary tastes. The tendency to give the names of books read years ago, or books that have been only casually glanced at, seems to indicate that some men are getting rather callous in matters of plain honesty. He who relieves himself with a "No one knows the difference," is a moral coward who dares not show himself in broad daylight. Character lurks between lines and in parentheses, and this person is enclosing in a parentheses an epithet which, uttered by some one else against him, might occasion violence.

Nor can the excuse be made that the list of books given is too limited. If all the works listed have been read, others from the supplementary list could be substituted.

To those who are honest enough to say that they do not care

for literature (not those who say so because it is a conventional thing for the engineer to be indifferent to literature and who therefore join the crowd for convenience sake) we should add that the list of books for summer reading has been prepared primarily for them. A little reading willingly and conscientiously done will soon develop the taste that is lacking.

The engineer who is more than an engineer, who is a human with wider sympathies and deeper insight than the pure technician, is the man whom we should emulate. Let us begin by doing our summer reading.

A. ELMENDORF, '14.

COLLEGE OF ENGINEERING NOTES

UNIVERSITY OF ILLINOIS MAKING HEAT INSULATION TESTS FOR NEW YORK CENTRAL LINES

Some rather interesting tests are being conducted by the University of Illinois for the purpose of bettering the heat insulating qualities of the walls of railway mail cars.

The postoffice department has for some time been trying to secure a car the walls of which would have a much smaller coefficient of heat transmission than the present type. Professor E. C. Schmidt, of the Railway Department of the University of Illinois, knowing of the trouble the railroads were having in trying to construct a better insulated car, took up the matter with Mr. A. R. Ayers, General Mechanical Engineer of the New York Central Lines, with the result that a number of experiments are being conducted for the New York Central Lines by the University under the direct supervision of Professor Arthur C. Willard, who is in charge of the Heating and Ventilating courses at the University. So far the tests have had to do with the amount of heat lost from the car with insulation between the plates and the post construction of the car.

As now constructed, the walls of a steel mail car consist of two plates about four inches apart, the outer 1/8 in. and the inner 1-16 in. in thickness. Between these plates are vertical steel channels of a modified form, which serve as reinforcement to the plates. The railroads have been working under the impression that the heat loss was intensified by conduction from the inner to the outer wall by this steel channel, and as a result have been placing a 1/4 in. layer of agasote insulating material between the steel plate and the lega of the channel. This is an expensive construction, as it is quite a problem to rivet these channels securely with the agasote in place. Moreover, this is

being done with no real knowledge of what effect the agasote has on the heat retaining qualities of the wall.

Professor Willard's apparatus consists of a box, the dimensions of which are six feet each way. The walls of the box are of ⅞ in. tongue and groove siding with 5 in. studding between. The air space is filled with granulated cork. This construction gives a well insulated wall. One side of the box is removable so that different sides may be substituted. The tests consist primarily in determining the heat resisting qualities of these different sides with various methods of insulation. Heat is supplied to the inside of the box by means of a resistance coil and the heated air is kept in circulation by an electric fan. The heat input to the box is figured from the total amount of current supplied to both the coil and fan. The current supplied to the fan must be taken into consideration, as its energy is dissipated in the form of heat which is taken up by the air in the box. The inside temperature of the box is ascertained by the average reading of six long-stem thermometers which are inserted at various points.

A coefficient of transmission of 0.096 was obtained using an insulated wooden side. A steel side with a ¼ in. layer of agasote under the channels gave a coefficient of 0.350. The next test to be made is with a steel side having no insulation whatever. After this, a test will be made on a steel section which has the space between the plates filled with some kind of insulating material. Professor Willard is inclined to believe that this method of filling the space between the plates will serve to materially reduce the heat loss. He holds the opinion that the heat loss is not due entirely to conduction, but largely to convection; the air against the inner wall becoming heated, rises to the top and passes over to the outer wall, where it loses its heat and falls, only to take up heat again and rise. Thus the air between the plates forms an endless chain which carries the heat from the inside of the car. By filling this space these convection currents will be broken up and their effect destroyed. The results of the tests are being anxiously awaited both by the University and the New York Central Lines.

Professor J. M. Bryant of the Electrical Engineering Department of the University of Illinois was one of the men called to testify in the suit of the City of Philadelphia against the Welsbach Company. The suit concerned the method of measuring the candle-power of lights and Professor Bryant was called as an expert on Illumination.

INVESTIGATION OF ELECTROLYTIC IRON

Mr. Trygve D. Yensen of the Electrical Engineering Department of the University of Illinois has, for the past two years, been making a special study of electrolytic irons with reference to their magnetic qualities. The aim has been to secure an iron of high permeability and small hysteresis loss and an iron four times more efficient than any now in use has been secured. A vacuum furnace was used for melting the iron, the pressure in the furnace being reduced to about one-half centimeter of mercury. Pure iron, when melted in the open air, will absorb a quantity of carbon and oxygen and so be of inferior quality, while iron melted in a vacuum does not absorb any of these elements, but remains pure. Various methods were used in cooling, tests being made to determine the effect of cooling slowly, plunging in brine, in liquid air, etc., each iron being tested to determine the magnetic qualities, metallurgical composition, chemical composition, strength, and critical temperature. Much valuable information has been gained by these experiments, the results of which are soon to be published in the form of a bulletin by the Engineering Experiment Station of the University.

DEPARTMENT NOTES

C. E. NOTES

On March 5, Mr. J. J. Burgraff, '14, gave an interesting talk on "The Subdivision of California Land," followed by an informal discussion. Mr. Lurie gave a brief talk on some subdivision work near Chicago.

At a meeting held March 19, J. H. Anderson was appointed on the Engineering Dance Committee. R. T. Reilly represented President F. T. Sheets on this committee. D. E. Riff, '14, talked on "Reinforced Floor Construction" and illustrated different floor designs with sketches.

Mr. L. J. Towne, Superintendent of Construction for the University, lectured on "Structural Engineering as a Profession" on April 2. The discussion on "Roads" by Prof. C. C. Wiley on April 23 was very interesting. The lecture was illustrated with a number of lantern slides.

On April 29, Mr. O. B. Kercher gave an interesting talk on "The Inspection of a Concrete Highway Bridge." Mr. Kercher was bridge inspector for the State Highway Commission during his vacation.

E. W. FREARK, '16.

MINING NOTES

The Miners held their first meeting of the year at the residence of Professor H. H. Stoek on October 2nd. Most of the old boys were back and many new students were present. Here the mining students had an opportunity to meet the two new members of their faculty, Professor E. A. Holbrook and Professor L. E. Young.

During the summer several new machines were installed in the mining laboratory and new equipment placed in the ventilation laboratory.

Several inspection trips were made during October and November to the mines and strippings about Danville.

Mr. R. Y. Williams, formerly of the Bureau of Mines, was appointed Director of the Illinois Miners' and Mechanics' Institutes, and the work was started January 1st under the supervision of the mining department.

On February 20th, the miners held one of the most successful smokers they ever attempted. The large number of new men who registered in mining the second semester turned out in full force and were welcomed into their new profession by the older members of the society. The most interesting part of the program was the speeches, which were as follows: "The Copper Strike in Michigan," by Professor Young; "Mining and Living Conditions on the Rand, South Africa," by Mr. Thos. Hail; "Coal Mining Conditions in Europe," by Mr. S. O. Andros; "The Duties of a Mine Surveyor," by Mr. H. E. Willson. These speeches were presented by men who had first-hand knowledge of the subjects which they discussed.

Bradley Stoughton, secretary of the American Institute of Mining Engineers, visited the Mining Department on February 25th. It was the intention of the student branch of that organization to tender him a banquet, but on account of the scarlet fever scare, it was prevented.

During Easter vacation the seniors made their annual inspection trip to the mines and quarries near La Salle, the factories of several manufacturers of mining machinery in Chicago, and the steel mills of Gary. At a meeting of the society after their return they gave a brief resumé of the trip.

Just before Easter a six weeks' course in mining was started under the direction of the Illinois Miners' and Mechanics' Institutes. This course was arranged to give instruction to the practical mining men of the state.

A lecture on the mining and Geology of Butte was given April

18th by Professor A. N. Winchell of the University of Wisconsin.

The Danville Bulletin of the Illinois Coal Mining Investigations was ready for distribution on April 18th. It is the first of a series of bulletins which will furnish much new information concerning the mining of Illinois coals.

On April 23d, the Juniors went to Danville to survey a mine as a part of the course in mines surveying.

S. T. WALLAGE, '15.

THE RAILWAY CLUB

The Railway Club has had a very successful year, practically all the men taking any course in Railway Engineering or Administration being members of the club. The instructors also take a great deal of interest in the club, always being ready to give a talk on some interesting railway subject.

The first meeting held in the school year was more of a social event than anything else. All railway men or men interested in railway work were invited to come, and the usual feed was had, being supplemented by a few talks from the instructors of the department.

At the second meeting of the year Mr. A. F. Comstock gave a very interesting talk on Railway Signaling. The railway signal was discussed from the first white and black ball signal up to the present automatic block signal.

On October 31, Prof. A. M. Buck of the Railway E. E. Department gave a very instructive talk on the Features of Electric Traction. The many advantages of Electric operation on heavy trunk lines were given, showing how the electric system was more economical than the steam system for certain lines.

J. A. Wilson, '14, gave a talk on American and Foreign Locomotives at the next meeting. The many differences in the construction of the locomotives was shown, among them being that European railway almost entirely have the cylinders between the drivers, while the American practice is to have the cylinders outside the drivers.

The Safety First movement is becoming more important every year, and on December 5 Mr. R. B. Keller gave an interesting talk on how the railways are taking up this very important point.

The railways of South America are in about the same stage of development that the American railways were probably fifty years ago. There are no through routes, and if a person must travel any distance he is very likely obliged to change cars five or six times. There is no uniformity in the track, there being

the broad, medium and narrow gauge lines, which in itself is a great drawback to the standardization of the railways. J. M. Fetherston, '14, gave a very good talk on the railways of South America on January 9.

"Physical Valuations of Railways" was the subject of a talk by Prof. M. H. Robinson. This work is becoming more important every year, and the Interstate Commerce Commission is giving this work a great deal of attention. Prof. E. C. Schmidt recently served as an examiner for the Commerce Commission at Washington, D. C., for candidates for the Board on the Valuation of Railways.

The Railway Department has finished its tests on the Illinois Central locomotive No. 958 and it has been returned to its old position of hauling drags over the Chicago Division.

The railway test car which has been designed at the University for the Government Railways of Japan has just been finished and is now in the locomotive test laboratory undergoing the finishing touches. After all the recording machinery has been installed, a set of thorough tests will be made of all the instruments to make sure that everything is in good working order. Then the instruments will be taken out and crated and everything shipped to Japan, where the car will be used to make tests on the Japanese railways.

E. M. Krabbe, '14

M. E. SOCIETY

The present year has not been a very successful one as regards membership in the M. E. Society. This is due mainly to the late date at which the opening smoker was held and a canvass for memberships made. Only a few meetings were held during the first semester and all of the talks were made by members of the faculty. However, the talks were all of the very highest class and were deserving of better attendance.

The present semester has been very successful thus far. At the offset a "feed" was held at the Y. M. C. A., the "eats" consisting of the usual cider, apples, ginger-bread and popcorn. The usual program of a few formal talks was dispensed with and instead the men gathered around in bunches telling all of the latest stories. "Lentie" proved to have the greatest variety and soon was the main attraction. Programs for the semester were given out near the close.

At the first meeting of the society after the "feed," Profsesor Leutwiler gave a talk on voting machines. Professor Leutwiler

has served on several voting machine commissions and is very well acquainted with the different kinds of machines. His talk was illustrated and gave a very good idea of how to vote on such a machine. The meeting was well attended.

On April 16, Mr. Koehlor of the educational department of the B. F. Goodrich Company gave a talk on the manufacture of rubber. It was a fine spring evening and only a fair crowd braved the weather and came to the meeting. Mr. Koehlor had samples of the various kinds of rubber, which were passed around, and also some enlarged photos of the operations in the gathering and manufacturing processes.

The program for the remainder of the semester consists of the following:

The Heat Treatment of Steel, by C. W. Lincoln, '15

The History and development of the Centrifugal Fan, by Frank L. Busey, '85.

The Organization of the Engineering Office of the Chief Quartermaster Corps of the U. S. Army, by Professor A. C. Willard.

The Experimental Department of a Manufacturing Plant, by A. F. Barron, '15.

Mr. L. H. Schickedanz has been elected junior member of THE TECHNOGRAPH Board to represent the M. E. Society.

E. E. SOCIETY

The combined A. I. E. E. and E. E. Society held a meeting about the middle of March, at which Dr. Knipp of the Physics department gave a very interesting and instructive discussion of the phenomena relating to the conduction of electric charges through vacua. By means of a large induction coil he applied an E. M. F. of several thousand volts to the terminals of a glass tube, similar in form to a Geissler tube. A vacuum of only a fraction of a millimeter of mercury was then produced in the tube by means of a mercury air pump, the different phenomena of light rays being discussed by Dr. Knipp as they appeared in the tube. He also showed experiments by means of which the velocity of the charged particles as well as the ratio of the charge on each particle to its mass could be easily calculated.

The next lecture was given a couple of weeks later by T. H. Aldrich, who is Supervising Engineer of the National X-Ray Reflector Co. He gave a very interesting lecture, and showed a large number of slides representative of the different types and uses of indirect lighting. One point which he brought out was that the reflectors must be kept free from dust. Actual experi-

ments showed that even in supposedly clean places the dust that settles on the reflector in one month is sufficient to absorb about ten per cent of the light. Another point brought out was that many of the so-called systems of indirect lighting are really not indirect at all, the defining characteristic he used being that at least half of the light must be obtained by reflection from the walls and ceiling.

Considerable interest has been taken lately in the iron produced by T. D. Yensen by means of the electric furnace. At a combined meeting of the A. I. E. E. and E. E. Society, held April 16, Mr. Yensen told of the work he has been doing and the results that are being obtained. His lecture dealt more especially with the magnetic properties of the iron, although the other properties were considered somewhat. By purifying his iron in a vacuum of less than a centimeter of mercury, he was enabled to obtain specimens 99.99% pure. This is probably the finest iron ever yet produced, and the results obtained by joining alloys with it may have far reaching effects on the iron industry of the future.

During the past year quite a few changes have been made in the E. E. department. The most important of these is probably the change in instructors. Last year we lost Mr. Loring, Hake, Wilson, and Dr. Berg, and gained Mr. Moore, Knight, and Beigler. All of the new men, as well as the old, have entered into the spirit of the work with the students and are accepted as friends as well as instructors. Professor Paine, with the aid of his assistants, has been ably filling the place left vacant by Dr. Berg.

Probably the most important action taken by the E. E. Society during the past year is its affiliation with the A. I. E. E. This was only made temporary, but it has worked out so well that very likely next year it will be made permanent.

E. A. James, '15.

THE YEAR'S PUBLICATIONS OF THE ENGINEERING EXPERIMENT STATION

61. Characteristics and Limitations of the Series Transformer, by A. R. Anderson and H. R. Woodrow. 1913. *Free upon request.*
62. The Electron Theory of Magnetism, by Elmer H. Williams. 1913. *Free upon request.*
63. Entropy-Temperature and Transmission Diagrams for Air, by C. R. Richards. 1913. *Free upon request.*
64. Tests of Reinforced Concrete Buildings under Load, by Arthur N. Talbot and Willis A. Slater. 1913. *Free upon request.*
65. The Steam Consumption of Locomotive Engines from the Indicator Diagrams, by J. Paul Clayton. 1913. *Free upon request.*
66. The Properties of Saturated and Superheated Ammonia Vapor, by G. A. Goodenough and Wm. Earl Mosher. 1913. *Free upon request.*
67. Reinforced Concrete Wall Footings and Column Footings, by Arthur N. Talbot. 1913. *Fifty cents.*
68. The Strength of I-Beams in Flexure, by Herbert F. Moore. 1913. *Free upon request.*
69. Coal Washing in Illinois, by F. C. Lincoln. 1914. *Free upon request.*
70. The Mortar-Making Qualities of Illinois Sands, by C. C. Wiley. 1914. *Free upon request.*
71. Tests of Bond between Concrete and Steel, by D. A. Abrams. 1914. Available May 1, 1914. *Free upon request.*
72. Investigations of Electrolytic Iron. T. D. Yensen.
73. Acoustics of an Auditorium. Dr. F. R. Watson.
74. Thermal Properties of Steam. Prof. Goodenough.
75. Tests of Electric Cars. (Railway Department.)

NOTE.—Nos. 72 to 75 not yet in print.

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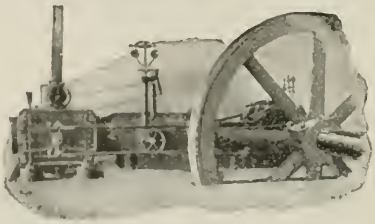

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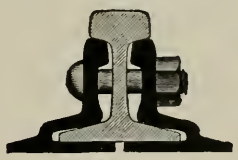

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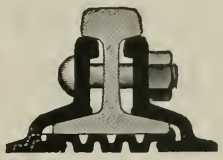

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